18.

Differential Effects of Estradiol, Estradiol Benzoate and Pregneninolone on *Platypoecilus maculatus*.

MARGARET CORDSEN TAVOLGA[1].
New York University and The American Museum of Natural History.

(Plates I-V; Text-figures 1-5).

Androgenic effects of estrogens have thus ar been described as affecting only secon- ary sex organs in mammals (Allen, Hisaw nd Gardner, 1939; and Witschi, 1939). In ne present work, data are presented to show onodal stimulation and androgenic effects of n estrogen in the platyfish.

The platyfish, *Platypoecilus maculatus* Günther, is a viviparous cyprinodont belong- ng to the family Poeciliidae. It has been sed frequently for genetic studies (Bellamy, 928 and 1933; Fraser and Gordon, 1929; Gordon, 1927, 1931, 1937a, 1947a and b), for tudies of melanoma (Gordon, 1937b, 1948a; Gordon and Flathman, 1943; Levine and Gordon, 1946), and for embryological studies Tavolga and Rugh, 1947), but until 1940 it as not used as an experimental animal for ndocrinological work.

In 1941, Cohen, Gordon and Nigrelli re- orted on the spontaneous development of onopodia in females of *Platypoecilus*, while n 1940 and 1942 Grobstein worked out the evelopment of, and endocrine effects on, onopodium differentiation. Cohen in 1942 nd 1946 did the first work on the effects of ex hormones on the platyfish. At that time e found that pregneninolone has an andro- enic effect upon the gonads and anal fins of he fish and that alpha estradiol benzoate has eminizing effects on the male. Pregneninol- ne, in mammals, has been known as a prog- stogen, although its effects have been dis- redited in recent years as ineffective and artially androgenic (Corner, 1942; Freed, 942 and 1943). As above indicated, it has een found since that time that on lower ver- ebrates, such as fishes, the hormone has an ntirely androgenic effect. In experiments reliminary to the present work, it was found hat the effects of free estradiol did not co- ncide with those produced by the benzoate ster, and it was decided to continue and ex- and this aspect of the work as well as to letermine the effects of androgens on the nale and estrogens on the female. Pregnen- nolone was used as an androgen with which o compare the effects of alpha estradiol when it was found that this substance did not exhibit strictly estrogenic activity.

MacBryde *et al.* (1942) found differential effects of estrogenic substances on the mammalian liver. It was decided, therefore, to investigate the effects of the treatment upon the liver of the experimental animals as a possible source of information as to the reason for the differential effects of the two estrogens. With these purposes in mind the present experiments were undertaken.

The author is indebted to Dr. Charles M. Breder, Jr., of the American Museum of Natural History and New York University for his aid and criticism in the progress of the work and in the preparation of the manuscript, to Dr. Myron Gordon of the New York Aquarium of the New York Zoological Society and New York University for his help and criticism during the experiments and for the stock of fishes[2] with which the work was carried out, and to Dr. Lester R. Aronson of the Department of Animal Behavior of the American Museum of Natural History for his generosity in supplying equipment and laboratory space. Thanks are due also to Dr. Robert Gaunt of Syracuse University, who provided the initial stimulus for the problem, and to Dr. Milan J. Kopac of New York University and Dr. Irwin Schwenk of Schering Corporation for obtaining the initial supply of alpha estradiol benzoate.

MATERIALS AND METHODS.

The fishes used for these experiments were platyfish, *Platypoecilus maculatus*, of the New York Zoological Society's Genetics Laboratory Culture 180 (Gordon, 1948b), their immediate offspring and those of several subsequent inbred generations. In this strain the males are the heterogametic sex (XY). The Y chromosome carries the "spotted" gene (*Sp*), regularly transmitted from father to son when a spotted male $(X)+/(Y)Sp$ is mated to the recessive female $(X)+/(X)+$. The effect of the *Sp* gene is such that

[1] Submitted in partial fulfillment of the requirements for the degree of Doctor of Philosophy at New York University.

[2] These animals were obtained from the Genetics Laboratory of the New York Aquarium, New York Zoological Society. The work of this laboratory is supported by a research grant from the National Cancer Institute of the National Institute of Health, U. S. Public Health Service.

groups of macromelanophores are distributed over the major part of the body. The pigment cells begin to show immediately after the birth of the animals, affording a convenient method of identifying males and females within a day or two after birth. The females carry the recessive gene for macromelanophores (+ or *sp*) and appear as gray. In other strains of the platyfish which do not possess this or a similar feature, sex identification is delayed until such time as the fish mature, when the anal fin of the male is transformed into an "intromittent" organ, the gonopodium. Experiments carried out on such fish necessitate knowledge of the ratio of males to females usually derived in a brood from these fish and the use of statistical methods in determining the deviation from such a ratio when the work involves the use of hormones which produce effects on primary and secondary sex organs. This type of analysis is unnecessary with the strain used.

In seven generations only one crossover occurred, and this was in the control group. An animal in that group appeared to be a normal female 21 mm. long, but on sectioning she was found to possess normal testes for a fish of that age (66 days). Fraser and Gordon (1929) indicated that crossing over of the sex chromosomes in the platyfish is likely to occur at the rate of 1%.

The experimental individuals were kept in two-gallon tanks, approximately eight immature specimens of both sexes to a tank. Plants and gravel were removed at the beginning of each experiment in order to secure more uniform conditions. The room in which the tanks were kept was maintained constantly at a temperature of 80° F., plus or minus 3°.

The fish were fed daily on a fresh liver-Pablum mixture (Gordon, 1943) in amounts such that each tank received approximately 1.5 cc. per week. The method of introduction of hormones received a considerable amount of attention. The literature contains accounts of hormone administration both by dropping hormones into the water and by injection (Berkowitz, 1937; Eversole, 1941; Grobstein, 1942a). It was felt that the animals used in these experiments were too small to receive injections, since at the beginning of treatment they were only two to ten days old and averaged only 8 mm. in length. Therefore, dropping powdered hormone into the tanks was attempted.

It was soon noted, however, that the animals learned early to distinguish between food and hormone. At first they ingested it freely, but after a day or two they were observed to ignore it completely and the powder settled to the bottom of the tank, where it remained until removed. Thus the greater part of the hormone was not utilized. The possibility that it may have dissolved and been absorbed was not overlooked, and experiments designed to check this possibility will be discussed later. However, since the solubility of the hormones is known to be relatively small, another method of more direct administration was attempted, and wa found to give good results.

The powdered hormone was introduced in to the semisolid liver-Pablum paste an thoroughly mixed. The food was given i small lumps each day and the fish were ob served to pick at and ingest it freely eac time it was given for the duration of the ex periment. They consumed the amount give in about twenty minutes and close observa tion showed that they did not reject any par of the food, nor could any be seen at the bot tom of the tank when later observed. Becaus of this it was assumed that the entire amoun was ingested, and with it all the hormon which did not dissolve in the twenty-minut period which was needed for ingestion. Al though no accurate measurement could b made of the amount taken in by any individ ual fish, it was seen that all the fish had ac cess to the food and that there was little fight ing among them for it. Each animal, there fore, received approximately the sam amount of food and of the hormone. The hor mone in oil preparation was mixed into th liver paste in the same manner, and though i changed the consistency of the paste to slight degree, the preparation which wa chosen contained a high concentration of hor mone per cubic centimeter and little of th solution was needed to secure the necessar concentration in the food.

The hormones used were pregneninolon (Pranone, Schering), alpha estradiol (Pro gynon DH, Schering), and alpha estradio benzoate (Progynon B, Schering). The firs two were prepared in tablet form. The initia supply of estradiol benzoate was in powde form and the remainder in solution in sesam oil. The two forms of estradiol benzoate pro duced indistinguishable results and so ar considered together.

The amounts of hormone used were selec ted in an attempt to secure doses whic would be adequate to gain results and at th same time avoid much of the toxicity whic was found to occur, especially from preg neninolone (see Text-fig. 1). Pregneninolon was used in doses of 5, 2.5, 1.25 and 0.625 mg per 3 cc. of food. Estradiol and the crystallin estradiol benzoate were used in doses of 0.5 0.25, 0.13 and 0.06 mg. per 3 cc. of food. Th estradiol benzoate in oil was obtained in am pules containing 1000 rat units per cubi centimeter of solution in sesame oil, corres ponding to 0.166 mg., and the doses give per 3 cc. of food measured 0.166, 0.083, 0.041 and 0.0275 mg. These dosages were obtaine by mixing 1, ½, ¼, etc. cc. of the solutio or the same fraction of tablets with 3 cc. o food.

Control tanks containing littermates o the experimental animals were run simultan eously with each experiment. In experimen where oil solution of estradiol benzoate wa used, tanks of littermates which were fe with a mixture of food and sesame oil alon were also used.

The doses were given for various interval

ying from ten days to seven weeks, and at end of each interval at least one male and female were removed from each experiital tank and from the control tank. They e immediately fixed in Bouin's picro-for- and preserved after fixation in 70% alol. Each fish was then prepared for furr study as follows: the anal fin or gonoium was removed, cleared and mounted ire, and the belly of each animal was slit facilitate infiltration of solutions. The ani- was decalcified in a nitric acid-phloroglucol mixture for a period of 24 to 48 hours, ending on the size of the fish, placed in eral changes of 70% alcohol to remove the d, and dehydrated by means of Dioxan. er infiltration in 60-62° paraffin, the anls were cut at 10 μ and the sections stained h Harris' haematoxylin and eosin, or with d fuchsin and aniline blue (modification of sson trichrome stain).

The sections thus obtained were examined ascertain the condition of the ovary or tis, and the general condition of the other ans, and the anal fins were examined for ns of structural changes which might inate a progressive shift toward maleness femaleness. The sizes of the gonads were ermined by measuring the widths of these nds. It was found that while the lengths of gonads were roughly correlated with the ndard length (length from the tip of the ut to the base of the caudal fin) of the mals, the width of the gonad was also coated with the development and apparent ivity of the gland as induced by hormone atment.

In order to determine size differences beeen the eggs of the treated animals and se of the controls, one or more widely sepated sections of each treated and control mal was subjected to analysis. The secns selected were as widely separated as ssible in order to insure that no duplicate asurements could be made on any egg. Exbt for this consideration, the sections were sen at random. In each case, 100 eggs re measured in order to obtain a good disbution and a sufficient and representative mple. The means and standard errors of e means were obtained and according to the rmulas given by Simpson and Roe (1939) e significance values were calculated. These sults are given in Text-fig. 4 and Table . In the case of the testes, the same method analysis was applied to primary spermaytes , secondary spermatocytes and sperutophores. In addition, an adult control ale was sectioned in order to afford a comrison between the testes of the treated ung animals and a normal adult testis. The stis of this animal was analyzed in the me manner.

Results.

Two hundred forty-six animals were used perimentally. Each experimental group ntained 26 to 33 animals when finally prered and sectioned. Since with the dosages used there was no statistical difference between those treated for different periods and with different dosages, the descriptions given will cover all periods of treatment and all dosages, except where otherwise indicated.

General Considerations.

As was stated above, the animals ate the hormone-impregnated food freely and there was observed to be no fighting among the members of any tank for greater amounts of food. Each pellet of food was eaten within about twenty minutes of its introduction into the tank, assuring almost complete introduction of the hormone into the animals. It was possible, however, that the hormone might be entering the animals by way of absorption taking place from the amount of hormone which dissolved into the water during the time when the food was present in the tank. In order to establish whether such dissolution took place, and whether, if it did, the dissolved hormone remained in an active state, two experiments were set up.

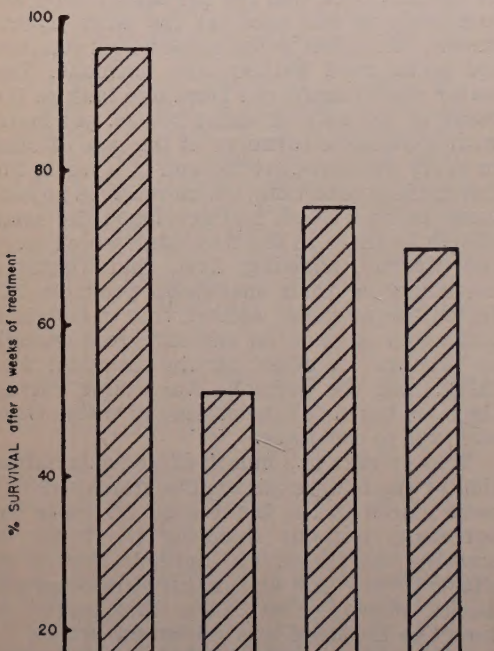
In the first of these, the water between two tanks was circulated through glass wool by a conventional air-lift filter in such a way that the water passed from one tank to the other without any undissolved particles passing in either direction. To the immature fishes of the same strain which were placed in the first tank was fed the same liver-Pablum paste as was used for the main experiments. The fishes in the second tank received the same food without the hormone. The water was transferred from one tank to the other at the rate of about 240 cc. per hour, with a complete turnover at the rate of once in every 30 hours. At the end of a week, the fish in the second tank, which received no hormone in their food, had developed the same effects as those in the first tank which were fed directly, showing, first, that dissolved hormones or their metabolic products affected the animals; second, that dissolution had taken place in an amount great enough to produce an effect on the animals; and third, that the hormone was stable during the time taken for the change of water from one tank to the other.

Three weeks to a month after the termination of the main experiments, immature fish were placed in the tanks used for these experiments without changing the water or washing the tanks. The animals showed no effects of any sort and matured into normal adults, showing that after this period of time the hormone was no longer active.

During the main body of the experiments, the effect of the hormones on the experimental animals was first noticed on the males which were treated with pregneninolone. Within four to five days after treatment was begun, when the animals were six to fifteen days old, and measured 8 to 9 mm. in length, each animal's anal fin was modified into the general form of a gonopodium. A few days later, the anal fins of the females in the same

tanks had also acquired this characteristic. At about the same time (ten to twelve days), the males in the estradiol tanks developed the same type of modification, also followed in a few days by the females. Note that the estradiol, while it had superficially the same effect, was delayed in its action in comparison to the pregneninolone. Those fish in the tanks treated with estradiol benzoate, both males and females, for the duration of experimentation never developed any structures even superficially resembling a gonopodium. That the gonopodia developed by the androgen-treated animals were not typical nor perfect gonopodia with the characteristic hooks, spines, serrae, etc., of the platyfish gonopodium will be discussed later. It should be said here, however, that they were modified in the male direction sufficiently to be considered greatly affected by the hormone treatment, and that the fins of the pregneninolone- and estradiol-treated animals reacted in the same general manner.

Pregneninolone in the amounts given had a serious effect on the viability of the treated animals (see Text-fig. 1). Forty-eight percent. (32) of these animals died before the termination of the experiment and therefore were not considered in the results given. It is believed, however, that this death rate must be a significant consideration in the general effect of the hormone on the metabolism of



TEXT-FIG. 1. Percentage survival of control and treated animals over a period of eight weeks.

the animals, and should therefore be includ in the general results. The effect of estrad was similar, but again quantitatively less, only 24% (17) of the animals treated in t manner succumbed. This number was s nificant as compared to the death rate of t control, where there was only 4% mortali but not as compared to the estradiol ben ate-treated group, since 30% (20) of t estradiol benzoate-treated animals also di

The locomotor activity of the treated a mals was not impaired in any way. Sex activity, normally absent at this stage of velopment, appeared precociously, and t tiny animals with miniature gonopodia we seen vigorously following the females, in manner suggestive of precopulatory behav of adults, as early as one week after the b ginning of treatment, when they were b two weeks of age. This type of activity co tinued until the end of the experimental p riod. The females of the group, although th exhibited the male type of behavior, show it to a lesser degree. Although they tend to follow each other, they did so less oft and less vigorously. Females were not se following males. In the estradiol benzoa tanks there was no evidence of male behav during the entire course of the experime on the part of either males or females.

Effect on Gonads.

Control Males.

All animals in the experiments were you healthy specimens, ranging in size at the e of the experimental period from 8 mm. f those treated for one week to 22 mm. f those treated for seven weeks. None of t animals at the end of the experiments we old enough to be normally sexually matu and they would not normally have become for about two months, as *Platypoecilus mac latus* matures at the age of about four six months under the laboratory conditio maintained here. At the ages of one to sev weeks, therefore, the testes were small co pact masses, fused but showing their p mary bilobed nature, their anterior ends a pearing between two coils of the intestine approximately the same cross sectional le as the caudal tip of the liver. They were a tached to the dorsal peritoneum by a sho mesorchium and in a few cases were se dorsal to the intestines. See Pl. I, Fig. 1. Th ranged in width from 0.08 mm. for the sma est animals (7.0 mm.) to 0.35 mm. for t larger ones (19.0-21.0 mm.). The young gonads could be seen to contain numero groups of cells (cysts) which could be or poorly differentiated from the main mass tissue, except under the higher powers magnification at which they could be se to be spermatogonia. Between these cysts e isted numerous connective tissue cells a fibers, making up the stroma of the glan The sperm duct in these smaller animals w poorly differentiated. In the larger spe mens, none of which was more than eig

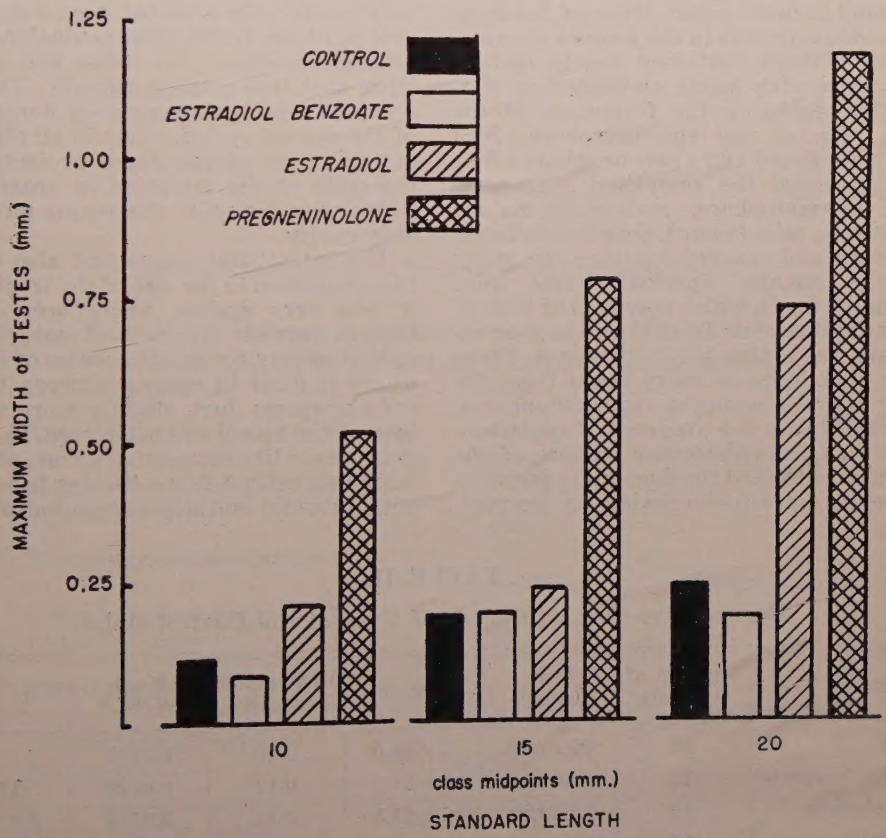
eeks old, the cysts were slightly better dif-
eentiated. They could be seen to be separ-
d from their surrounding stroma, which
ss less distinct, and the smaller cysts had
w taken up a position relatively peripheral.
this stage these cysts measured 20 to 33 μ
width. A few larger cysts, 36 to 46 μ in
dth, could be seen toward the center of the
nd. These, under higher magnification,
ld be seen to be primary spermatocytes.
ese cysts, when present, surrounded the
w well formed duct. These descriptions
firm those of Wolf (1931) on the devel-
ment of the testis in *Platypoecilus macu-
us* at this stage. In no case did the gonads
ntain any cellular formations acceptable as
condary spermatocytes, spermatids, ma-
re sperm or spermatophores.

ales Treated with Alpha Estradiol Ben-
ate.

The testes of these animals showed a
ghtly retarded development as compared
th the controls (see Pl. I, Fig. 2). Their
e range was equal to that of the normals
.10-0.34 mm.). The mean was 0.19 mm.
ne two testes were slightly separated, indi-
ting an inhibition of their development
ward a fused gland. The gland in general
nsisted of a number of peripheral cysts,
rrounding stroma cells which were abun-
dant and ducts which were slightly less well formed than the normal. The cysts measured 11 to 21 μ in width, but since the testes were so small there were not enough of them to justify a statistical analysis. A few larger cysts were present, but they were less distinctly demarcated than those of the control. There were no statistically significant differences between the widths of the testes of this group and those of the controls ($P = .05$—see Table II).

Males Treated with Pregneninolone.

Pregneninolone has been shown to have androgenic activity in the guppy by Eversole (1941) and in the platyfish by Cohen (1946). It was expected, therefore, that it would have a similar effect here. That expectation was justified. The testes of even the smallest of the males thus treated showed definite stimulation effects. These testes were significantly larger than those of the control ($P = .001$), measuring from 0.36 to 1.50 mm., with a mean of 0.81 mm. (see Text-fig. 2 and Table II). In each case, whether the animal was treated for a short period or a long one, the results were the same except for the general size of the gland, which had sufficient time to grow larger in the animals which were treated for a longer period. The cellular effects, in



TEXT-FIG. 2. Growth of control and hormone-treated male gonads as determined by measurements of testis widths.

TABLE I.

Comparative Sizes of Gonads in Treated and Control Females.

Treatment	Number of animals	Mean length	Range	Mean gonad width	Extremes
Control	13	13 mm.	8-19	0.42 mm.	0.11-1.40
Estradiol benzoate	13	17 mm.	8-24	0.31 mm.	0.11-0.61
Pregneninolone	12	16 mm.	13-23	0.45 mm.	0.30-0.85
Estradiol	16	16 mm.	13-23	0.45 mm.	0.20-0.88

every case, were the same. The effect was to stimulate the testes to maturity far ahead of the time at which it would ordinarily be functional. Cysts of spermatogonia were present, measuring 30 to 51 μ in width, but in all the animals of the group the spermatogenic process had gone far beyond the stage of spermatogonia and primary spermatocytes into secondary spermatocytes, spermatids and spermatophores, the presence of which is the usual sign of a functional gland (see Pl. I, Fig. 3). The groups of cells had become differentiated into cysts of maturing primary spermatocytes measuring 93 μ plus or minus 2.1 (see Table III), secondary spermatocytes measuring 97 μ plus or minus 1.5, or later stages, each cyst containing only one stage of spermatogenesis, as is found in mature fish. Many of the cysts contained spermatids in the process of growing tails. Others contained nearly mature spermatozoa with heads embedded in Sertoli cells, beginning the formation of the typical ring of the spermatophore. Still others were found (69 μ plus or minus 1.5 μ) which possessed the completed ring form of the spermatophore, containing mature spermatozoa, tails inward, dark heads forming a ring and massed together. In many cases the released spermatophores were found in the ducts, which is typical of the testis of the mature fish. In all the cases spermatogenesis was active in all its stages; there was an abundance of every stage from the earliest spermatogonia to spermatophores. In a general way the progress of spermatogenesis was from the outer portion of the gland inward toward the duct, and spermatogonial cysts were found mainly at the periphery progressing through primary and s ondary spermatocytes to spermatids a spermatophores which were located near t center of the gland and adjacent to the duc Since the animals were not treated for m than seven weeks, it is possible that t maximum effects were not obtained. Exha tion effects in *Lebistes*, in which all sperm togenesis is in very late stages and no sper atogonia are present (Eversole, 1941), w not found. It is possible, therefore, tha longer treatment would have produced glan showing lack of germinal elements such those described by him.

The position of the glands was also d ferent in the treated fish. In the controls this age they tended to be placed, as sta before, between the coils of the intestine, a only rarely were situated dorsal to this g eral position. In the pregneninolone-treat animals, however, the testes had grown large that they pushed dorsally. They oft occupied a position completely dorsal to th of the normal gonad, while in all other ca at least part of the gland projected abo the coils of the intestine in cross secti Often they occupied the major part of t body cavity.

The interstitial tissue had also chang In comparison to the size of the treated gla it was very sparse, being seen as me threads between the cysts of maturing ge cells. However, toward the center of the glan where it filled in spaces between the cy and the sperm duct, slightly more abunda interstitial tissue was often seen. In the ma it appeared like connective tissue, often wi large oval cells. A few collecting tubules lin with cuboidal epithelium could also be see

TABLE II.

Comparative Sizes of Gonads of Treated and Control Males.

Treatment	Number of animals	Mean length	Range	Mean gonad width	Mean W/SL*	t	P
Control	13	15.1 mm.	7.0-21.0	0.20	0.0122		
Estradiol benzoate	12	16.0 mm.	8.5-21.5	0.19	0.0125	.17	.0
Pregneninolone	10	16.2 mm.	8.5-21.5	0.81	0.0518	8.9	.0
Estradiol	17	15.2 mm.	8.0-22.0	0.35	0.0209	2.4	.0

* W/SL equals the ratio of the gonad width divided by the standard length.

TABLE III.

Sizes of Spermatogenetic Cysts of Treated and Control Males.

Treatment	Structure of testis	Number of animals	Sample	Mean diam. (micra)	$\pm \sigma_M$*	General effect
Control at experimental age	Primary sp. cytes	14				Few—insufficient for significant count
	secondary sp. cytes	14				None present
	sp. phores	14				None present
Control mature male	primary sp. cytes	1	100	60	1.4	
	secondary sp. cytes	1	100	73	1.3	
	sp. phores	1	100	49	.9	
Estradiol benzoate	primary sp. cytes	12				Very few
	secondary sp. cytes	12				None present
	sp. phores	12				None present
Pregneninolone	primary sp. cytes	10	100	93	2.1	Enlarged over mature control
	secondary sp. cytes	10	100	97	1.5	Enlarged over mature control
	sp. phores	10	100	69	1.5	Enlarged over mature control
Estradiol	primary sp. cytes	2	100	56	1.4	Not significantly smaller than control
	secondary sp. cytes	2	100	56	1.1	Significantly smaller than control
	sp. phores	2	100	42	1.1	Significantly smaller than control

Significance Values Calculated from Means in Table III.

Significance values are calculated as the difference between two means divided by the standard error of the difference.

Primary spermatocytes

	Estradiol	Pregneninolone
Control mature male	2.0†	13.0
Pregneninolone	14.8	

Secondary spermatocytes

	Estradiol	Pregneninolone
Control mature male	9.9	12.1
Pregneninolone	22.2	

Spermatophores

	Estradiol	Pregneninolone
Control mature male	5.0	11.2
Pregneninolone	14.6	

* σ_M equals standard error of the mean.

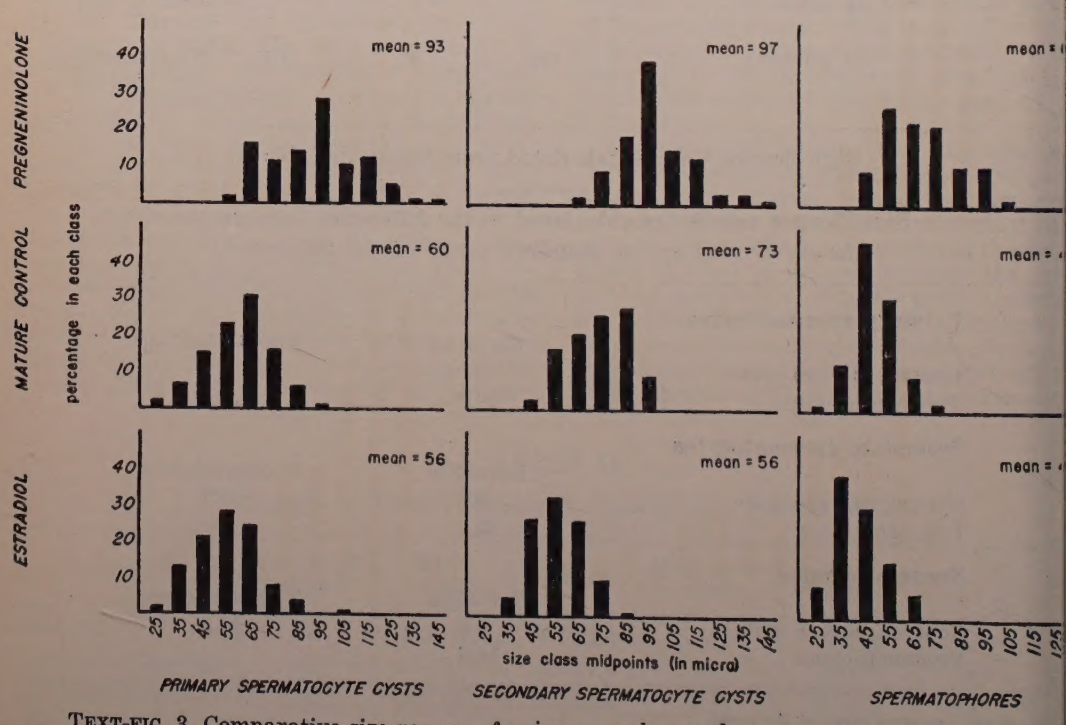
† These values are not to be considered significant.

These observations corresponded very well to Wolf's (1931) description of the interstitium of a young mature male.

Males Treated with Alpha Estradiol.

In mammals it has been found that alpha estradiol is usually an estrogenic hormone (Willier, 1939; Witschi, 1939), although in some cases paradoxical effects have occurred which have affected the secondary sex organs. However, the gonads are not ordinarily changed in these cases. When the present experiments were in their earliest stages, it was found that apparently this was not true in the platyfish. Therefore further experiments were carried out in order to determine the effects of this substance. The animals in this group fell into two sets, the difference being one of size and depending not at all on dosage or length of treatment. In all animals under 18 mm. in length, the testes presented a normal control picture. The testes were small, compact, showed spermatogonia and early spermatocyte stages, compared well in size with those of the controls, except for a very small increase, and generally showed no significant effects. In all animals, however, over 19 mm. in length, the developmental picture was entirely changed. The gonads in these cases were intensely stimulated organs, showing all stages of spermatogenesis. Discrete cysts of primary and secondary spermatocytes, 56 plus or minus 1.4 μ, and 56 plus or minus 1.1 μ, respectively, spermatogonia 25 to 30 μ at the periphery, and normal spermatophores of 42 plus or minus 1.1 μ at the center were present. Note that the siz of these cysts were significantly smaller th those of the pregneninolone animals (s Text-fig. 3 and Table III). The ducts al were large and well formed, typical of t ducts of a mature male, and they were fr quently filled with spermatophores. The spermatophores, like those of the pregneni olone-treated animals, were well formed ar showed no sign of precocious extrusion fro the cysts or of abnormal cells despite the comparatively small size (see Pl. I, Figs. and 5). The picture approximated that of an mals treated with the known androgen pre neninolone, in every detail except size. seems, then, that estradiol, far from bein an estrogen, acts much like an androgen the stimulation of the testes in these fis The position of the testes in the abdomin cavity of the animal and the appearance pr sented by the interstitial tissue corresponde in every way to the pregneninolone-treate animals.

In order to determine the size relationsh of these stimulated spermatogenic cysts those of the normal testis, an adult untreate male was sectioned and prepared in the san manner as the experimental animals. As wit the experimentals, 100 cysts of each typ primary and secondary spermatocytes ar spermatophores, were measured by mea of the ocular micrometer and statistical a alyses were made (see Table III and Text-fi 3). In each case the cysts of the pregne inolone-treated animals were significant larger than those of the adult control ar



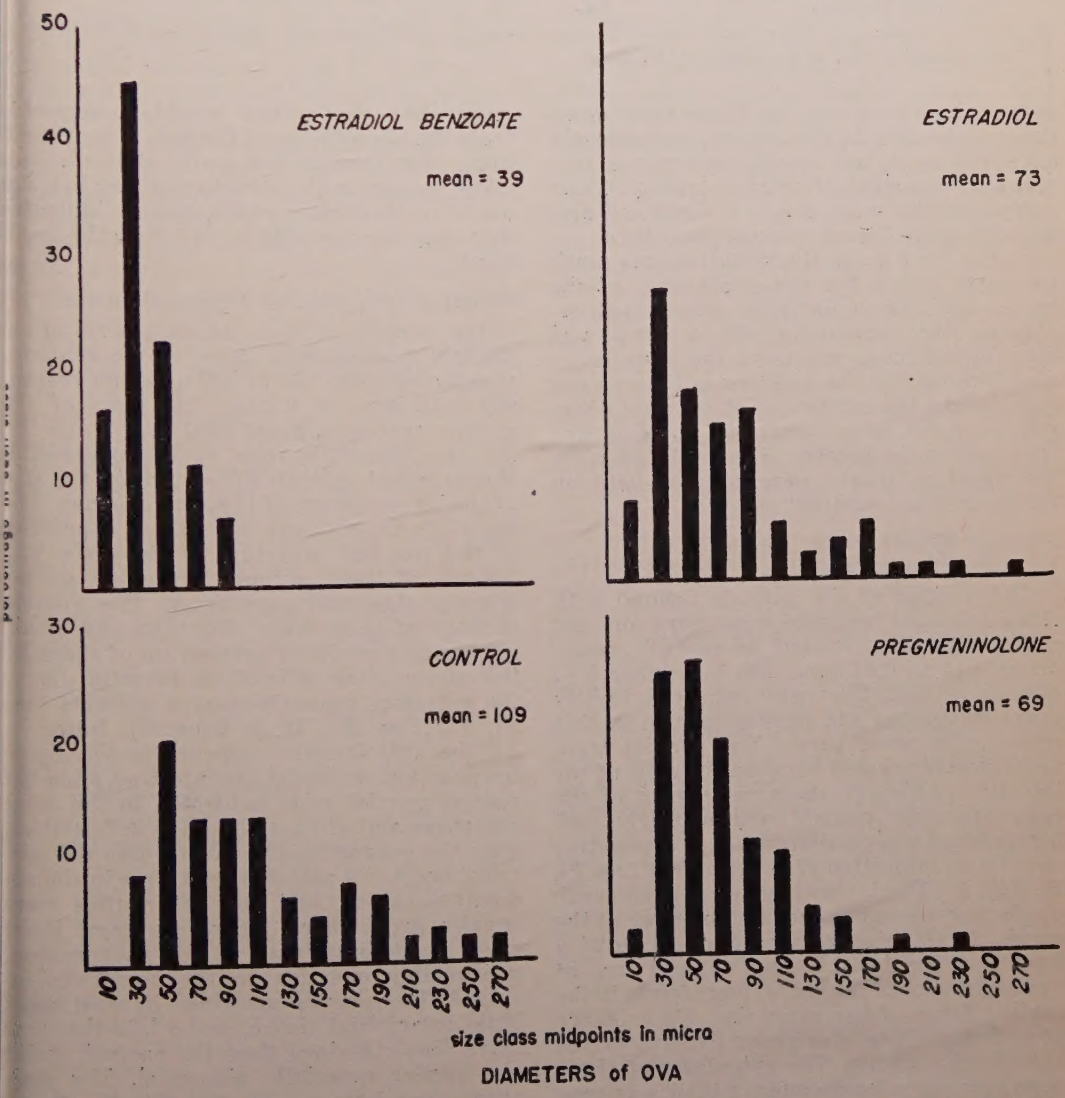
TEXT-FIG. 3. Comparative size ranges of primary and secondary spermatocyte cysts and spermatophore cysts of pregneninolone- and estradiol-treated animals as compared with those of a normal adult male.

ith one exception the cysts of the estradiol-reated animals were smaller. In the case of ne primary spermatocytes the cysts of the stradiol-treated animals were not signifi-antly smaller than those of the control adult.

ontrol Females.

The typical female ovary of a platyfish of wo to eight weeks of age was located in se-ial cross sections between two coils of the ntestine, suspended from and approximat-ng the dorsal peritoneum. The ovary ranged size from 0.11 to 1.40 mm. and the mean alue was 0.42 mm. Posteriorly it lay free f contact with surrounding organs, and far osteriorly, just anterior to its posterior argin, it lay almost if not completely free n the abdominal cavity. At the young stages tudied here, it consisted of a single mass omposed mainly of young circular or ovoid vocytes, before, or in the larger animals during, the process of yolk deposition. The mean size of these ovocytes was 109 μ plus or minus 6.5 μ (see Text-fig. 4 and Table IV). The ovary as a whole was compact, little if any space being present between adjacent eggs. Any space which was present was almost filled with small amounts of stroma. Stroma also filled spaces between the outermost eggs and the peripheral flattened epithelium (see Pl. II, Fig. 6).

In the younger stages the ovocytes were yolk-free, with slightly reticular cytoplasm and a lighter-staining nucleus. Each nucleus contained one or two deeply-staining, prominent nucleoli. The nucleoplasm itself was reticular in appearance, studded with chromatin granules. These larger eggs were located mainly at the periphery of the organ and each was bounded by epithelial cells constituting the follicle. The younger cells, oogonia, 21 to 45 μ in diameter, were situated



TEXT-FIG. 4. Comparative size ranges and distributions of eggs of control, estradiol benzoate-, pregneninolone- and estradiol-treated females.

TABLE IV.

Sizes of Eggs of Treated and Control Females.

Treatment	Number of animals	Sample	Mean diam. (micra)	$\pm \sigma_M$	General effect
Control	12	100	109	6.5	
Estradiol benzoate	13	100	39	2.1	Great inhibition
Pregneninolone	12	100	69	3.9	Partial inhibitio
Estradiol	16	100	73	4.8	Partial inhibitio

Significance Values Calculated from Means in Table IV.

	Control	Estradiol benzoate	Estradiol
Pregneninolone	5.2	6.7	0.6*
Estradiol	4.3	6.1	
Estradiol benzoate	10.2		

* These values are not to be considered significant.

nearer the ovarian cavity. They were sometimes imbedded in the stroma immediately surrounding it, but usually maintained contact with the epithelium of the cavity. Their cytoplasm was more deeply stained and presented a more homogeneous appearance.

In the later stage the situation was much the same except for the appearance of the larger eggs. These had now grown considerably in size, measuring 100 to 280 μ, and their cytoplasm presented a far more reticular appearance than was true of the younger eggs. Near the periphery of some of them yolk granules were discerned, but this was true only in the largest of them. In all cases intermediate stages were present between the largest and smallest eggs.

Females Treated with Alpha Estradiol Benzoate.

The ovaries of the animals treated with alpha estradiol benzoate were more compact and smaller than those of the controls, measuring 0.11 to 0.61 mm. and averaging 0.30 mm. in width. The eggs appeared tightly pressed together and were deformed by this pressure in some cases. The ovaries were more closely pressed between the coils of the intestine. Although the arrangement of the eggs appeared normal and a fairly well formed duct was present, the eggs themselves showed an inhibition of development (see Pl. II, Fig. 7). The larger eggs were peripheral, gradating to smaller ones in the center of the organ. In size they ranged from 11 to 96 μ (see Text-fig. 4 and Table IV), and none of them approached the size of eggs found in the control fishes of the same size. No evidence of yolk deposition was present in any of the eggs in this group. The cytoplasm of these eggs was more homogeneous than was true of the ova of the controls, and they compared in size and structure to a much younger stage than that which would be expecte from the age and size of the fish. It is evident then, that though few acute abnormalitie were present in the structure of the individ ual eggs, their size and appearance indicate that they were greatly inhibited by the treat ment.

Females Treated with Pregneninolone.

The ovaries of these animals were agai slightly smaller than those of the controls measuring from 0.30 to 0.85 mm. and averag ing 0.45 mm. in width. The sizes of th groups overlap a great deal (see Table I) but the largest ovaries of the pregnenin olone-treated animals did not reach the siz of the largest ovary of the control group. Th main effects, however, were those appearin in the size and structure of the eggs. Th ovaries of these animals presented an ex tremely abnormal appearance. The greate number of them were shrunken and small appearing completely pressed out of shape b the surrounding coils of the intestine, as i the estradiol benzoate-treated animals (se Pl. II, Fig. 8). It is doubtful, however whether this shrunken appearance was due t the pressure caused by the intestine, since th control ovaries were subjected to the sam pressures and did not show the deformities Also the pregneninolone ovary, like the con trols, lay, at its posterior end, free in the ab dominal cavity, and the deformities were equally great there. Therefore some othe cause must be assigned to this phenomenon presumably one due to the hormones in volved. The ovaries contained in most case little interstitial tissue, and while this wa more deeply stained than the normal, it did not appear especially abnormal. The egg themselves, however, showed definite effects They were seldom as large as those of the con trol, having a mean size of 69 μ plus or minu

29 μ (see Text-fig. 4 and Table IV). In a few ases large eggs could be found and these ere the most nearly normal-looking ones. ven they appeared degenerate, however, owing deeply-staining cytoplasm, slightly rregular nuclei and a partially deformed appearance. The remaining eggs were unirmly deformed in shape, the main body of hem having irregular depressions in their ides and usually one concave side, so that he individual eggs took on the appearance of ushed-in balls. The nuclei were also misshapen, showing elongations and irregularides, each one staining deeply. The cytoplasm often had a mottled appearance, in ontrast with the even staining of the conrol. This resulted, presumably, from some ffect on the cytoplasm, which caused parts f it to stain deeply and others lightly, without any regularity. Another significant point as in regard to the size of the eggs. All those hich were not included in the groups of arger eggs mentioned first were extremely mall as compared to eggs in the same stage f a control, measuring from 11 to 60 μ. No vidence of yolk deposition could be seen in ny individual eggs.

In most of these ovaries the duct was poorly formed and the edge of the epithelium was ragged and abnormal, showing cells and bits f tissue sloughing off into the duct.

Two variations of these conditions were ound. In two cases the ovary was large but he eggs were scattered and large spaces ere present between them (see Pl. II, Fig.). While the eggs in these specimens were ot usually as deformed as they were in the ases described above, they were deeply tained and appeared to be in a state of degeneration. As above, few eggs could be found hich were as large as those of the control f the same age and size, but several appeared which had been approaching this size nd condition before treatment with hormones was begun. These eggs showed approximately the same irregularities as the arge ones described above. The epithelium urrounding the gland was ragged and shredded in many places and the cells of the duct ere ragged.

In two other cases a definite bi-partite vary was found. In one of these the eggs ere fairly large and normal-looking, measuring between 90 and 130 μ (see Pl. II, Fig. 0), and appeared to be comparable to the ggs of the majority of the control ovaries. n the other case, however, the eggs were mall and degenerate-looking, measuring bout 40 to 60 μ, and were stained deeply, howing deformities. In this ovary there appeared two definite ducts, one for each half f the gland, which showed fairly regular pithelium. The first case contained a duct hich was wide and flat horizontally, apparently serving both sides of the gland. It s believed that this remaining evidence of he bi-lobed nature of the embryonic gonad ay have been caused by the inhibitory effects of the androgenic hormone applied. All variations of the ovarian conditions were used together in making the statistical analysis of the eggs in this group.

Females Treated with Alpha Estradiol.

In general terms, the ovaries of this group showed the effects expected of an androgen. The results were very similar to those produced by pregneninolone. The majority of the animals possessed ovaries which appeared as shrunken masses, with deformed eggs such as those described for the pregneninolone-treated animals, staining poorly and in a mottled fashion. The size also, of both the ovaries and the eggs, was comparable to the size of those of a pregneninolone-treated female, since measurements of the ovaries ranged from 0.20 to 0.88 mm. with a mean size of 0.45 mm. (see Table I). The eggs had a mean size of 73 plus or minus 4.8 μ, a size which is not significantly different from that of the pregneninolone-treated eggs.

There were several exceptions to this general picture. In two cases the ovary showed the same scattering which appeared in some of the pregneninolone-treated animals (see Pl. II, Fig. 11). The same larger degenerating eggs, and the same type of atretic appearance in the small eggs was present. In one case, there appeared a bi-lobed ovary such as that described above, which possessed one duct to serve both parts of the gland. In this specimen the eggs were small, measuring 40 to 60 μ, and while not as deformed as the typical eggs of this group, some atypical shapes were present and the eggs generally stained more deeply than the controls. In some cases there appeared a variety of degeneration not seen in the pregneninolone-treated group. In these ovaries there were a few eggs which appeared to be almost normal, both in size and general appearance. The remainder of the comparatively large gland was composed of a substance which at first appeared to be adipose material. Upon closer inspection, however, it was concluded that at the places where this material was seen, there had once been large eggs in the process of yolk deposition (see Pl. II, Fig. 12). The eggs had apparently degenerated, since the masses contained no recognizable structures, and left behind them a mass of fatty yolk-filled material. Vacuoles were present, which showed the presence of lipoids. Some yolk granules were to be seen. At certain points about the periphery of these masses there appeared epithelium of a largely degenerate nature which was broken and sloughed in parts. Since there had been several eggs of this nature, it might have been expected that there would be some type of separation between them. For the most part, however, this was not true, and the masses were indistinguishable from one another, showing no evidence of where one egg ended and another began. In some places a portion of the above-mentioned epithelium remained, to give some indication of the limits of the egg, but this was true only in a few cases. The masses

of material were of various shapes so that no indication remained of the original shape of the ovum. The remaining eggs were of the small deformed type mentioned above and were pushed to one side of the organ. The ovary, because of this peculiar content, was quite large, although the egg content was extremely small. The appearance of the organ as a whole was a degenerate one. The outline of the organ, even where the eggs were present, was ragged and appeared degenerate, as the epithelium was ragged and uneven in contrast to the smooth epithelium of the control.

Effects on the Anal Fin.

Grobstein in 1940 published a complete description of the developmental stages in the transformation of the platyfish's anal fin into the gonopodium. In 1942, however, he partially changed the terminology used in order to conform to prevailing taxonomic usage. In all the following descriptions, the terminology used in the 1942b paper will be employed.

Control Males.

The anal fin of the control male fish at the ages studied here was one in which no differentiation or growth had taken place in the change from the undifferentiated fin toward the typical gonopodium. The fin looked like the female fin of the same age (see Pl. III, Fig. 13). The fins were well formed, the third ray slightly thicker than the others. The fourth and fifth rays, particularly the fourth, projected slightly beyond the others. No bifurcations were present in the younger fins and the larger ones possessed only primary bifurcations. Secondary and tertiary bifurcations which, according to Grobstein, depend on age, had not yet appeared in any of the fins studied. No growth of the third ray, which indicates the beginning of differentiation into the gonopodium, had begun in any of the fins. The only difference between the male and female control fins at this age was the presence of macromelanophores in the male fin, due to the *Sp* gene. The females did not possess these macromelanophores.

Males Treated with Alpha Estradiol Benzoate.

Fins of the males treated with alpha estradiol benzoate presented the same picture as did the controls. In all the fins, which came from animals not more than eight weeks old, no differentiation of any sort tending in the male direction was seen. The fourth and fifth rays projected slightly beyond the others, but no more so than is normal in the female fin and certainly not enough to give the impression that they are beginning the gonopodial growth phase (see Pl. III, Fig. 14). They appeared as normal fins for this age of fish, but since no animals were carried to maturity it is not known whether the hormone would have been enough to prevent gonopodial differentiation entirely.

Males Treated with Pregneninolone.

The anal fins of all animals in this group were affected by the hormone treatments. In the case of the smallest animals, ten days to two weeks of age and 8 to 9 mm. in length which had been treated for one week to ten days, the transformation had proceeded only into Phase I, and all these fins possessed third rays which were segmenting and growing producing an elongation of the cephalad portion of the fin. All those treated for three weeks or longer, however, showed a completely modified picture. In these groups, every fish possessed an almost completely differentiated gonopodium (see Pl. III, Fig. 15). Most of these were almost perfect, although a few existed which were lacking in certain elements present in a normal fin. The usual element missing in such an incomplete fin was the spines, which in most cases, if present, were flattened and smaller than normal. Some fins were seen where no spines at all were present. Since the oldest fish in the group were not more than eight, or at most nine weeks old, it can be assumed that this precocious development was due to the effects of the hormones administered. That the modifications of the fins correlated well with the growth and differentiation of the gonads is further evidence for this assumption.

Males Treated with Alpha Estradiol.

Anal fins of males treated with alpha estradiol could be placed in two groups. These corresponded directly to the division which occurred in the description given already of the gonads of this group. In those animals which were below the size of 18 mm. at the end of the experiments, the fins, like the gonads, did not show the usual effect of the androgen. Each of the anal fins observed in this group was in Phase I of growth and elongation of the third ray. The fins appeared as modifications of the female condition in which the third, fourth and fifth rays had grown long enough to project beyond the others to about one-third of their length. In the majority of the animals, the third ray was found to be segmented as in Phase I, rather than like the control, in which segmentation was far less definite.

The group comprising those animals which reached a size of 19 mm. or more contained fins which were modified far more toward the typical male condition. They were almost complete but showed more variability than did the pregneninolone-treated males. Elements which were present consistently were the subterminal segments with the terminal hook, the elongation of the fourth ray, with its cephalic ramus curved in a cephalad direction, spines and proximal serrae. Elements which were absent or incomplete in the imperfect fins were distal serrae, the spoon and spoon support, and the blade. These were absent in different combinations. Although the fins of this group were not complete, they showed a definite tendency toward the male form (see Pl. III, Fig. 16). If

as Grobstein postulates, the gonopodium is under the control of the testis, the present evidence supports that view.

Control Females.

The anal fin of the female control animals, like the males at this age, showed no signs of differentiation toward the adult form. The structures possessed by these fins were those typical of the young female (see Pl. IV, Fig. 17). The fins did not differ materially from the adult female type except that, as in the male, only primary bifurcations of the fourth to ninth rays had taken place. The third, fourth and fifth rays projected slightly beyond the others, as is normal. The thickening of the third ray present in the male fin at this age was present to a lesser degree in the female. No macromelanophores were present, since the female does not carry the *Sp* gene. Except for this last distinguishing characteristic, present only in this strain, the fins were structurally similar.

Females Treated with Alpha Estradiol Benzoate.

In animals treated with this estrogen, the condition of the anal fin was indistinguishable from that of the control fin (see Pl. IV, Fig. 18). The third, fourth and fifth rays showed the same slight extension. The third ray was again slightly thicker than the others. Bifurcations of the rays in animals of the same age were identical.

Females Treated with Pregneninolone.

The fins of the animals in this group presented a varied picture. None of them possessed a complete and normal gonopodium, but neither did any possess the typical female anal fin. All animals possessed fins which had progressed far beyond the first phase of gonopodium formation and many had gone into the third phase (see Pl. IV, Fig. 19). All animals had completed the preliminary growth phase, in which the 3, 4, 5 ray complex segmented and pushed out in the cephalo-distal portion of the fin to form a promontory there. Elongation of these rays continued throughout Phase II of gonopodium formation. At the beginning of this growth new segments appeared in the third ray, and at the end of the first phase there were generally nine segments present (Grobstein, 1940). During the second phase, these segments increased in number to twenty-two when the gonopodium had completed its growth. All animals in the group possessed at least ten segments and specimens were found in which the complete number was present. At the end of Phase II differentiation of the various specialized parts of the gonopodium began. The great majority of the animals had arrived at this stage. In many, however, the differentiation was aberrant, showing certain completely differentiated parts, while other parts, which should have differentiated concurrently, were still in an undifferentiated or partially differentiated state. Plate IV, Fig. 19, shows a gonopodium of this group in which the differentiation was almost complete. This fin had progressed as far as the "blade stage" (Grobstein) and shows most of the elements of a complete gonopodium in a more or less normal state. The fin possessed proximal and distal serrae, the blade, the spoon and spoon support, the terminal hook and subterminal segments and other elements. Other gonopodia were found which possessed good segmentation of the third ray and a perfect terminal hook, which should not appear until the time at which the distal serrae differentiate and after the formation of the proximal serrae, but both sets of serrae were missing. Such varied differentiations were common but the general rule in this group was partial or complete differentiation of all parts, many with slight deformations.

Females Treated with Alpha Estradiol.

Alpha estradiol was found to have almost the same effects as pregneninolone, although they were somewhat delayed (see Text-fig. 5). Thus the majority of the fins in this group had begun differentiation but had progressed to a lesser degree than those of the previous group. All the fins had entered the first or preliminary growth phase, since all of them showed at least the segmentation and strengthening of the third ray, and the resulting promontory forming on the cephalo-distal border. Most of them had in addition entered the second phase, in which growth had gone on to form a great elongation of the fin. About one-third of them went on into the third phase, in which they showed various stages of differentiation. In this group no complete gonopodia were found, but many fins showed the beginnings of the differentiated elements. There were present terminal hooks together with subterminal segments, proximal serrae, a few sets of distal serrae, the cephalic turning of the fifth ray, and the cephalic ramus of the fourth ray. All these, however, while they appeared together in a few animals, were usually present in less complete combinations. Alpha estradiol, while it is androgenic to a great extent, since it induces the formation of gonopodia, does not produce nearly as complete gonopodial structures as does pregneninolone (see Pl. IV, Fig. 20). The presence of an androgenic effect, however, is easily seen.

Effects on the Liver.

Control Animals.

The liver in the platyfish was divided into several large lobes. Lobules were not separated as in the mammal, and the entire gland appeared as a compactly arranged mass of cells. Cords of cells were present, though not as distinctly as in the livers of higher forms. The cells themselves measured about 8 μ in diameter and were weakly eosinophilic. The nuclei averaged about 2 μ in diameter. The stroma was poorly distinguished from the epithelial cells. The mass of homogeneous-

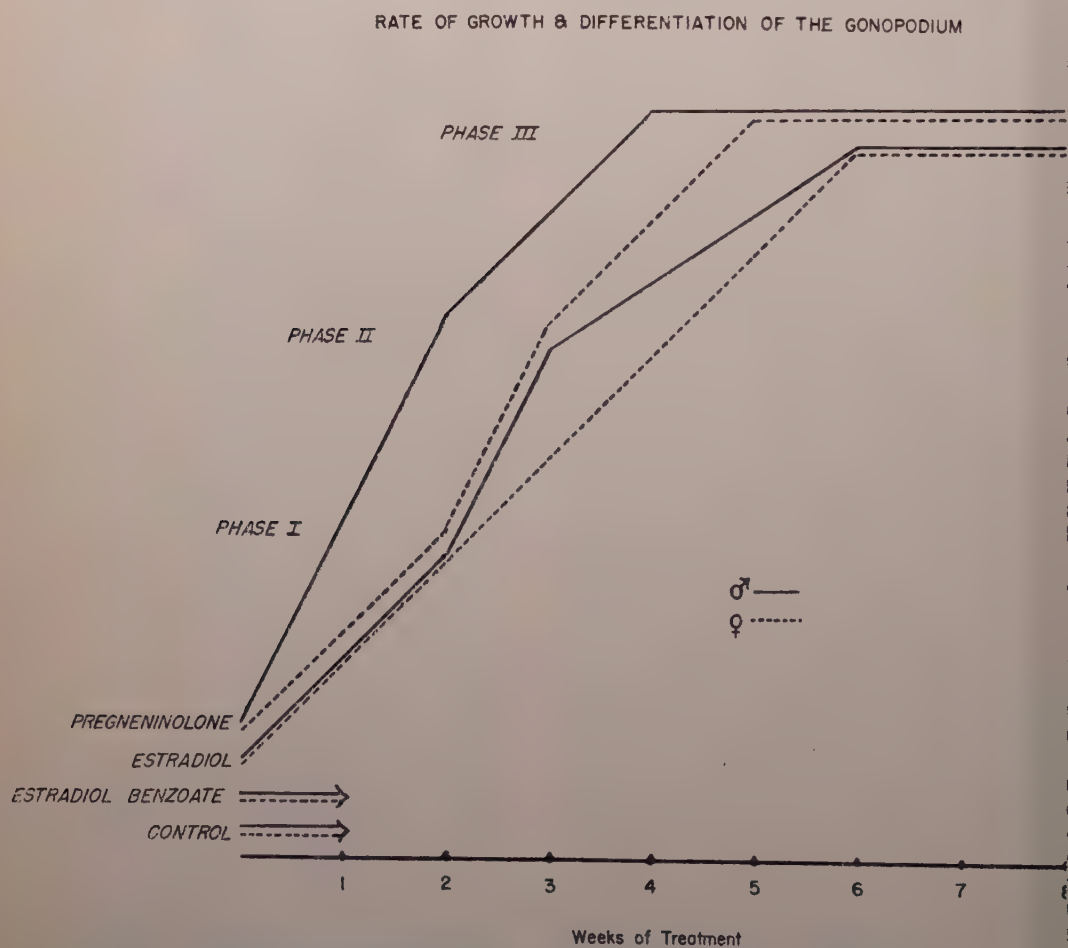
appearing cells was profusely supplied with blood vessels of all sizes. The nuclei, from 2 to 3 μ in diameter, were nearly circular and thickly granular. The cells were of three types, non-vacuolated with weakly eosinophilic cytoplasm, partially vacuolated with one or two vacuoles filling about one-third of the cytoplasm, and a third type in which larger vacuoles filled most of the cell. In all the vacuolated cells, the vacuolated ends aggregated together in a direction farthest from the blood vessels, producing pale blotches in the structure of the liver from 10 to 20 μ in diameter and very irregularly placed. The predominant type of cell was the partially vacuolated one. The second cell type in order of predominance was the one which was non-vacuolated and weakly eosinophilic. See Pl. V, Fig. 21.

Animals Treated with
Alpha Estradiol Benzoate.

The liver cells of these animals averaged 8 to 12 μ in diameter. Three types of cells were present, one non-vacuolated and weakly eosinophilic, another containing a vacuole which filled one-third to two-thirds of the cytoplasm, and a third which was highl vacuolated. The predominant type was tha in which one-third to two-thirds of the cyto plasm was vacuolated, followed by the nor vacuolated type. The organ as a whole pre sented a compact appearance much like tha of the control. The stroma network resemble that found in the control. No degenerativ effects could be noted. See Pl. V, Fig. 22.

Animals Treated with Pregneninolone.

The cells of the livers of these animal averaged from 10 to 15 μ in diameter, bein generally much larger than those of the con trol. The cells were all more or less vacuo lated. The type of cell which predominate was one in which the cytoplasm was occu pied almost completely by a large vacuole The vacuoles occupied, on the average, abou nine-tenths of the cytoplasm and as a direc result the nucleus and remaining cytoplasm were pushed to one side. The general ar rangement of the cells about the capillarie was as in the control and the entire orga presented a highly vacuolated appearanc (see Pl. V, Fig. 23). Vascularization ap peared increased, with a capillary for every



TEXT-FIG. 5. Graph showing growth of gonopodium of control, estradiol benzoate-, pregneninolone- and estradiol-treated animals.

seven to ten cells. The stroma network appeared more distinctly as a result of the extreme vacuolization of the parenchyma cells. The entire organ showed changes in structure, fatty in nature as demonstrated by the application of Sudan IV in frozen sections. The controls used for these reactions were normal livers of the same age, which showed comparatively few sudanophilic globules. The experimental animals, on the other hand, showed an abundance of these globules in their liver cells.

Animals Treated with Alpha Estradiol.

The liver cells in these animals averaged about the same size as those of the estradiol benzoate-treated animals, but the great majority of them showed vacuoles. Occasional cells showed the extreme vacuolization of the pregneninolone-treated livers, nine-tenths of the cell being occupied by a vacuole. For the most part, however, the cells contained vacuoles which occupied about one-half their volume and there appeared frequently cells with several small vacuoles instead of one large one. In general, the organ showed signs of far greater vacuolization than the control, and, therefore, partial changes similar to those shown by the livers of the pregneninolone-treated animals, but in a stage which was far less advanced. See Pl. V, Fig. 24.

Discussion.

Regnier in 1938 made a comprehensive survey of the history of fishes as experimental animals in sex hormone studies, and in addition described her own experiments on *Xiphophorus hellerii* with anterior pituitary hormones and ovarian and testicular powders and extracts. Essenberg (1926) described sex reversal in *Xiphophorus*. Blacher in 1926 found that testicular hormones are necessary for secondary sex characteristics in *Lebistes*. Castration and implants of gonads in *Xiphophorus* was carried out by van Oordt and van der Maas (1926). Berkowitz, in a series of papers (1937, 1938, 1941a and b), described the effects of estrogens and mammalian gonadotrophins in *Lebistes*, while Eversole (1939 and 1941) worked on the effects of androgens in this animal. In two papers in 1941 (a and b), Turner tested the effects of androgens on *Gambusia*. Scott (1941 and 1944) worked on the effects of steroids on the skeleton of *Lebistes*.

Eversole (1941) mentioned that testes of *Lebistes* treated for 42 days with pregneninolone showed all stages of spermatogenesis, with later stages predominating, that the spermatids and spermatophores produced were abnormal, and that in animals treated for 50 days, later stages in spermatogenesis were present almost exclusively, spermatids and spermatophores were atypical and that the gonad was generally in a degenerate state because of a rapid maturation of the germinal elements which left few spermatogonia. He also stated that the epithelium of the ducts tended to dismember at that time and that the stroma was hypertrophied. These observations were not seen in the present studies. Most of the animals, it is true, were not treated for more than six weeks, but some were treated for seven weeks, and even these did not show the degeneration of the gonad which was described by Eversole. Whether this difference was caused by the difference in experimental animals used, by the different method of administration of the hormone, by differences in dosages or ages, or by different conditions under which the animals were kept, is not clear. However, the gonads of the animals in the present work, while they showed great stimulation, were seen to contain germinal elements and abundant primary and secondary spermatocytes as well as spermatophores. This was true whether the animals were treated for two weeks or for seven. In the case of the animals treated for six to seven weeks, the picture of the gonad was equivalent to a normal mature testis, both in size and in quality of the elements contained. Spermatogonia were present, both primary and secondary spermatocytes were abundant, and the later stages of spermatogenesis were abundant and appeared normal. No signs of degeneration of any sort could be distinguished. As was stated in the results, it is possible that a longer period of treatment might have produced the exhaustion effects spoken of by Eversole.

Winge (1934) has shown that sex reversal may be detected by genetic means in the guppy. These reversals, however, were always from female to male. It is evident, however, that the sex determining mechanism in the guppy is less stable than that of the platyfish, since only two cases of sex reversal in *Platypoecilus* have been mentioned in the literature. Both of these were naturally-occurring phenomena (Breider, 1942; Gordon, 1947a). No sex reversal in the platyfish has ever been reported as having been induced by hormonal or any other means. Because of this relatively unstable sex mechanism in the guppy, it is easier to understand why Berkowitz (1937) was able to secure sex reversal and ovotestes in this form. No such phenomena were found in the present work. Although degeneration of the gonads was common as a result of hormone introduction, no sign of any transformation in the gonads was obtainable, either from male to female, or from female to male.

Berkowitz (1937, 1938, 1941), in work on the guppy, mentioned several hormones and combinations of these which were administered, and combined the results into a general statement. It is possible, therefore, that the divergent results of one or more of the hormones given by him went unnoticed because of this procedure. Although the results appear to be consistent, no mention is made of exactly which results were occasioned by which hormone and slight differences which might have led to a suspicion of the present findings might have been overlooked. A re-

grettable tendency evident in many papers is to administer "estrogens" without regard to which estrogen is being administered. The present work indicates that such a procedure is not safe.

Essenberg in 1923 stated that the oviduct in *Xiphophorus* was derived from a fusion of the two embryonic components of the ovary in such a way as to leave a space between them which later developed into the oviduct. Wolf (1931), on the other hand, who worked out the embryology of the gonads in the platyfish, stated that the oviduct originated by what may be considered the classical method, the degeneration of the medulla of each embryonic gonad accompanied by the development of the cortex (Willier, 1939). Goodrich *et al.* (1934) found that the oviduct of the guppy originated in the same way. Two such opposing views in two forms which are comparatively closely related seems to be unusual. Evidence for the double origin of the oviduct, in which the duct develops in two parts, one in each embryonic ovary, fusing to form one duct when the ovary itself fuses (Wolf's version), is given by the occurrence of the degenerate ovary under androgen treatment found in this work which possessed two distinct ducts. Such a condition, under the terms of Essenberg's hypothesis, would be unlikely. A further investigation into the origin of the oviduct in *Xiphophorus* would seem to be in order.

Regnier (1938), in her description of the origin of the oviduct in *Xiphophorus*, quoted Essenberg, but since this phase of her work was a review of the literature, no further evidence was to be found there. Regnier mentioned the effects of testis powder as producing bi-lobed and retarded ovaries in *Xiphophorus* when these animals were treated when very young. She also mentioned the comparatively great mortality present when this treatment was given, but said that with the addition of anterior pituitary lobe powder to the water in which treated individuals were placed, the mortality markedly decreased. After injections of testosterone for two months, her animals showed mature sperm in the testes, but no mention is made of presence or absence of spermatophores. Therefore it is not known whether the treated males in that group were fertile. She also discussed sex reversal due to hormones and the prevention of sex reversal by injections of appropriate hormones, but since it is known that the sex determining mechanisms of *Xiphophorus* are somewhat labile (Essenberg, 1926; Witschi, 1939), these results are not inconsistent. Mention was made of certain residual bodies which were derived from the degenerating follicles of the sex reversing ovaries and which traveled to nearby organs where they established themselves. Although evidence of such bodies was sought in the surrounding organs of the fish in the present work, no results were obtained.

Cohen in 1942 and 1946 treated female platyfish with pregneninolone and males with estradiol benzoate. He found at that tin that estradiol benzoate had feminizing e fects on the male platyfish over a twelve-we period. The other results produced were sir ilar to those found in the present experimen within the time limits used here, except th Cohen showed evidence that mature ova we found in normal control ovaries of fish only eight weeks old. In the entire group control females used in the present wor only one such ovary was found. This lack yolk-filled eggs in the ovaries was not co sidered unusual, since, although growth rat vary with environment, feeding and oth factors, *Platypoecilus*, even under ideal co ditions, does not usually mature until the e of the fourth month after birth or later, will be shown. Under normal conditions, mature ova would be expected to occur unt or just before that time. The effects of pre neninolone which were repeated in the pre ent experiments were in the main more pr nounced than those shown in Cohen's wor probably because of the larger amount hormone actually introduced into the fish a result of the different method of admini tration used here. It is believed that th method has been more effective, since t main portion of the hormone was introduce into the fish orally. However, the experimen run subsequently show that some of the dru was dissolved into the water, either durin the time when the food lay at the bottom the tank or after it was egested or excrete by the fish in a still potent state. That thes drugs affected the fish within a short tim through whatever means they became di solved, is also evident. The evidence brough out by the later experiment showed, howeve that the hormones are not stable unde aquarium conditions for more than abou three weeks, since after that time immatu fish introduced into the tanks with the sam water showed no effects whatsoever. Whethe the hormone was destroyed by the micr scopic population of the tank, adsorbed t the glass, or otherwise inactivated in som way is not known, but after that time it wa no longer present in a form which had an perceivable effect on the fish. Further wor is being done to determine the exact tim when this inactivation takes place, and als if possible, what the cause for the inactiva tion may be.

As to the effects of estradiol benzoate o the male, Cohen showed no figures on the d velopment of either the control or the treate testes for eight-week-old fish, and therefo it is difficult to compare results at that ag In the present work, however, the testes s treated were slightly retarded in differentia tion though not in size because of the admi istration of the hormone. Whether these e fects are similar to those found by Cohen fo an eight-week period is difficult to judge, b cause his descriptions did not cover tha period.

Some support for the theory that differe esters of the same hormone may bring abo

different effects was given by Grobstein (1942b), when he found that different esters of testosterone may show different effects on the regenerating anal fin of the platyfish. Even this paper, though, showed that all the esters used produced masculinization of the fin, as might have been expected. That a hormone and its ester should bring about diametrically opposed effects is unique. Grobstein also showed that the effects of these hormones is not to produce a normal gonopodium, but one that is imperfect. That evidence is substantiated here. In all cases there was produced a fin which was not precisely like the typical male gonopodium as it is seen in a normal adult animal. Even in those cases where the differentiated parts appeared to be almost normal, two differences in size were noted. The fin as a whole was smaller than the normal, and within this smaller fin the proportions existing between the length and width of the fin were changed. The 3, 4, 5 ray complex in each smaller fin was approximately one-third shorter than would normally have been found in a fin of the same width. The cause of this difference is apparently the result of differentiation of the fin beginning before it had time to grow to its full length, because of the relatively rapid action of the hormone. In the normal fish, the testis develops more slowly and therefore apparently controls the fin in such a way as to produce a lower amount of hormone until the fin has reached its maximum length, at which time the testis releases more hormone and differentiation takes place. This theory of hormone levels controlling the growth and differentiation patterns was postulated by Turner (1941b) and was adopted by Grobstein.

It should be established that under normal developmental conditions the young fish involved in these experiments would not have matured for about two months after the termination of the treatment, since they mature at approximately four to six months of age. Littermates of the experimental animals matured under conditions equivalent to those used in the experiments within these time limits, and averaged five months from birth to sexual maturity.

It can be assumed that a testis may be considered functional when it is producing spermatophores. Although no correlation has been found as yet to support this assumption in hormone-treated animals, it is always found that a normal functional male possesses spermatophores, while a non-functional male, otherwise normal, or an immature male, does not. Because of this evidence, it is assumed that the testes of the animals treated with pregneninolone, and the larger animals treated with estradiol were functional. Even if free sperm are produced under experimental conditions, the fish will not be sexually functional because of the necessity for transferring the sperm in a clump from the gonopodium of the male to the vent of the female. If this transfer is not carried out by way of the spermatophore, the sperm will presumably be lost in the water and fertilization will not result. Therefore, the important feature of the pregneninolone-treated testes was the large number of spermatophores present in both the acini and the duct. Since the normal testis at this age shows none of these features, the indication is that a great stimulation had occurred. Another feature to be mentioned is the difference in reaction of fish of the same age and size to the two hormones which produced stimulation of the testes. In the case of pregneninolone, the stimulation was a steady one, producing in every fish some sign of stimulation, the amount of growth and differentiation depending on the size and age of the fish. It was, however, never completely without effect. This may be seen from the sizes of the testes shown in Text-fig. 2 and Table II. Alpha estradiol, on the other hand, produces quite a different effect. In all the small fish, those below and including 18 mm., the effect was negligible. The testes appeared like normal control testes of the same age. When, however, the fish reached the size of 19 mm., the effect was different. The testes of the fishes of this size were immediately and greatly stimulated (see Pl. I, Figs. 4 and 5), and the testes resulting appeared to be functional, considering the great number of spermatophores present in the acini and duct.

As to the difference in size of the spermatogenic cysts present in the two types of treated animals, it is possible that the sudden arrival at a threshold level of hormone in the case of estradiol was responsible for a rapid differentiation of the gland, causing the smaller size of the spermatogenic elements. The pregneninolone-treated animals, which received a longer and steadier stimulation, were capable of producing cysts which were larger than those normally seen (see Text-fig. 3).

In order to suggest an explanation for the above effects and the others found in the present work, several assumptions must be made. First, it is well known that the liver of mammals inactivates steroid hormones which pass through the portal circulation (Biskind and Mark, 1939; Burrill and Greene, 1942; Cantarow *et al.*, 1943; Heller, 1940; Israel *et al.*, 1937; Segaloff, 1943; Talbot, 1939; Teague, 1941; Westerfeld, 1940). It is assumed that the same action takes place in the liver of teleosts. Some hormones, however, are inactivated more than others. Estradiol is inactivated more than estradiol benzoate because the benzoate ester protects the molecule from destruction. According to Heller (1940), the oxidation of the estradiols takes place at carbon 3 in ring A. Since the benzoate radical is attached at this position, its presence protects the molecule from oxidation (Segaloff, 1943). Therefore it can be assumed that the effective dose of estradiol, that is, the dose which produces the effects in the animal, is less than the effective dose of

estradiol benzoate, if identical oral doses are given.

The toxicity of the hormones must also be taken into consideration. Plate V, Fig. 23, shows the appearance of the typical liver of an animal treated with pregneninolone. The cells are greatly enlarged and vacuolated and are presumably in a condition caused by the relatively great toxicity of the pregneninolone, which may be interpreted as a type of fatty change. Because of this toxicity, the liver, which at first probably rapidly inactivated the hormone, was rendered unable to do so, and the main portion of the hormone passed through the liver intact, producing a large effective dose and intense effects. The estradiol, which is partially inactivated, causes also a partial vacuolization of the liver, suggesting a cumulative effect on the liver, which results in an increase in effective dose. This eventually has an effect on the gonads.

If these hypotheses are true, they present new evidence for the action of abnormal quantities of metabolic substances on the liver, since till now the only concusive evidence for the inhibition of inactivation by the liver has been derived from work on experimental Vitamin B deficiency (Biskind and Biskind, 1941, 1942, 1943; Biskind, 1946).

A further assumption concerns the stage of growth and differentiation in which the gonads are found during the period of the experiment. During this period the testes are, for the purposes of this explanation, in a relatively undifferentiated state and not yet under the influence of the pituitary. Gonadotrophic hormones are known to be present in fishes (Scheer, 1948). There is evidence to support the above assumptions. The testes, as shown by Text-fig. 2, grow very little during the period of the experiment. They contain essentially the same elements at the end of eight weeks as they possessed about one week after birth. The ovaries, on the other hand, grow considerably during the same period, and yolk deposition is begun and progresses considerably. The ovaries and eggs are much larger at the end of the period than they were at one week of age. The growth of the gonads is known to be under the control of the pituitary (Matthews, 1939a).

If these assumptions are admitted, at least as possibilities, a hypothesis may be advanced as to the method by which the hormones produce their results in these experiments.

In the case of the testis, the first effective doses of pregneninolone were small because the substances were largely inactivated by the liver tissue. These relatively small doses stimulated the pituitary rather than inhibited it because of the smallness of the dose. The estradiol had a delayed effect because it continued to be inactivated for a longer period of time, and therefore needed a longer period of time in which to reach an effective dose. The dose which was effective in the case of estradiol was a cumulative one and required a longer period in which to operate and a larger animal on which to operate because of some type of threshold reaction. The estradiol benzoate went through the liver tissue undestroyed and reached the pituitary in doses large enough to cause an inhibition rather than a stimulatory effect. Thus the testis, which was not yet under pituitary control, showed little effect from the administration of this drug.

In the case of the ovaries, which were already under pituitary control, the effects were different. The smaller doses of estradiol and pregneninolone acted as partial inhibitors, shown by the partial inhibition of the eggs in these specimens, while the estradiol benzoate, again passing through the liver undestroyed, caused an almost complete inhibition of growth of the eggs.

To suggest an explanation for the action on the gonopodium is a more difficult problem. In both males and females, the effect on the gonopodium was similar. Pregneninolone stimulated at least some growth in all gonopodia, and all older animals treated for a longer period of time showed almost perfect transformation of the fin. Estradiol stimulated all gonopodia to a slight growth, and the largest ones to the same type of differentiation shown by the pregneninolone animals though the differentiation was slightly less advanced. Estradiol benzoate had no effect on any of the animals. There are a number of hypotheses which may be advanced.

First, the gonopodium might be under purely genetic control. It is known that this is not true because the treated females showed differentiation to a gonopodium as readily as did the males.

Second, the ovarian hormone might inhibit the gonopodium. If we can assume that an inhibited ovary is producing little or no hormone, the above hypothesis cannot be true because under these conditions a greatly inhibited ovary would allow a better differentiated gonopodium than a partially inhibited one. The estradiol benzoate-treated ovary was inhibited to the greatest degree but there was no gonopodium, while the animals which possessed partially inhibited ovaries formed well differentiated gonopodia.

Third, the reactions cannot be due to a non-specific reaction to steroids because the different substances produced different effects.

Fourth, if the reactions are due to the action of the fish testis hormone, or to an androgenic effect directly, it must be hypothesized that estradiol has a direct androgenic effect, while an effect based on dosage difference would be more plausible, since in mammals the substance has an estrogenic effect.

Fifth, control from the pituitary gland entirely could explain the effects in the males where pregneninolone and estradiol stimulate the pituitary. In the females, however, the pituitary, according to the above assumptions, and based on its action on the gonads

hhibits the ovaries, and presumably would ot at the same time stimulate the differenation of a gonopodium. This of course asumes that the gonadotrophins secreted by oth male and female pituitaries are qualitively identical and stimulate the gonads the animals in which they exist. This has een shown to be true for amphibians (Rugh, 935).

Sixth, the theory that pituitary control dus male gonads or androgenic hormone nuse the effects is the most nearly complete xplanation. In this case, pregneninolone and stradiol stimulate the pituitary and therore stimulate the gonopodium through the onad. Estradiol benzoate inhibits the pituiary. Since the testis is not as yet under pituitary control, the testis shows no effects. o androgenic hormones are produced and ne lack of these produces, in turn, lack of gonopodium. In the females, however, an ndrogenic effect of the substances adminstered is necessary to explain the results. regneninolone and estradiol inhibit the ituitary and through it inhibit the ovary. he pituitary inhibition plus the androgenic ffects of the hormones cause the differentiaon of the gonopodium. Estradiol benzoate nhibits the pituitary, but, having no andro-enic effect, does not cause the formation of ne gonopodium.

A detailed cellular examination of the pituary gland in these fish may reveal signifiant differences between controls and experiental animals, presumably involving the ells which secrete gonadotrophic hormones. his may furnish a partial explanation for he results described above and indicate whether the action may take place through he pituitary or is a direct effect of the hormones upon the gonads, as has been shown to appen in other animals (Nelson, 1937). A areful examination of the interstitial tissue f the testes may also aid in determining the ossible effects of the hormones upon this issue.

These hypotheses were constructed in an ttempt to correlate the actions of the varius hormones on the gonads and on the anal in. Perhaps the effects on the two are entirely separate, however. The effect of the pituitary may be brought in to account for the effects on the gonads, but an androgenic effect of estradiol and pregneninolone would account alone for the effects on the gonopodium. It cannot be assumed, however, in view of the evidence brought out by estradiol benzoate treatment, that the effect is the paradoxical estrogen effect mentioned above caused by high dosage with estrogens. The effective dose of estradiol benzoate is higher than that of the others because it is protected in the liver. Therefore, under these conditions, one would be led to expect that it would produce a more definite effect than either of the other hormones. Since this is not true, some other hypothesis must be advanced to explain this effect. The other possibility which is most plausible is one in which the hormone has a directly androgenic effect.

The fact that the hormones which were used produced uniform results in spite of more than a tenfold range in dosage is an unusual finding. The toxicity which was found to be present with large dosages has also been found in mammals, but no sub-maximal results were found here.

It might have been useful also to treat the fishes with other benzoates as a control for the possible action of the benzoate ester exclusive of estradiol. The use of an inactive free compound with an active benzoate ester would be helpful in this work.

Turner (1941 a and b) brought to light various factors affecting the growth of the gonopodium. He stated that, first, the growth of the gonopodium depended on a certain low concentration of hormone and the differentiation of the fin depended on a higher concentration; second, that there existed certain dominances in the ray complexes which governed the differential growth of the various rays in such a way as to produce what we know as a complete gonopodium if the fin is left undisturbed; and third, that castration at any time during the growth of the gonopodium would stop its growth, while the administration of androgens thereafter would renew its growth. These findings on *Gambusia* have important bearings on the present studies. It was suggested above that the effect of estradiol was a cumulative one. This might account, on the basis of Turner's first statement, for the anal fin growth shown by the smaller estradiol-treated animals, where no differentiation was present. Pregneninolone caused an immediate and sustained effect on the gonopodium, suggesting that this hormone reached the threshold level almost immediately. Such a hypothesis would aid in explaining the effects on both testes and gonopodia.

As to the effect on the females, the hormones, as suggested above, may have had a direct effect on the fins.

The differential growth of the 3, 4, 5 ray complex was apparently governed by a low concentration of hormone. Dominance then shifted, according to Turner, so that the rays outside the 3, 4, 5 complex were subordinated to these three. This might explain the rapid growth of these rays in the young estradiol males and others in which a low level of hormone existed.

Castration with the effect of termination of growth of the fin, followed by androgenic restimulation, shows that the testis itself is not necessary for the growth of the fin, but that a hormone similar to that produced by the testis is required. This might aid in explaining the cases in which the females grew well-formed gonopodia.

The above hypotheses are far from clear and more work must be done in order to determine the explanation for these seemingly opposite and confusing effects. Hypophysec-

tomy, castration and a combination of the two performed on animals which were later treated with hormones would aid in determining the mechanisms which govern these effects. Preparations for such work are going on now.

More work is necessary on the general problem of the differential effects of these two estradiol compounds. The exact stage when the differential effect on the male begins should be studied in more detail. Smaller dosages should be used in an attempt to discover a dose small enough to secure a less than maximum effect, as such an effect does not appear in the present work. Finally, an investigation into the differential effects of more compounds related to these should be carried out, since the exact effect of any one of them is now doubtful, whereas heretofore they have been used interchangeably, at least on experimental animals.

Summary.

1. The experimental animal used was a strain of the platyfish in which males could be distinguished from females at birth as a result of a Y chromosome sex linked, spotted factor, whereas usually the sexes are indistinguishable until maturity, when the anal fin of the male is transformed into an intromittent gonopodium.

2. The hormones used were alpha estradiol, alpha estradiol benzoate and pregneninolone, a synthetic progestogen. These were administered by mixing the powder or oil solution with the food.

3. Pregneninolone exhibited a strong stimulating effect on the males, with precocious maturation of the testes and well-formed gonopodia. In females, development of the ovaries was inhibited, and gonopodia produced.

4. Estradiol benzoate was inhibitory on the testis and greatly so on the ovary. No gonopodia were produced.

5. Alpha estradiol had no effect on the testes of males under 18 mm. in standard length and produced slight growth of the anal fin. In males over 19 mm. in length, the testes were greatly stimulated and large, well-formed gonopodia were found. All females so treated showed ovarian degeneration and partial to nearly complete gonopodia.

6. Studies on the liver showed that pregneninolone and estradiol produced great vacuolization of the parenchyma cells and resulted in an organ which showed fatty changes, while the benzoate-treated livers appeared like those of the controls.

7. It is to be emphasized that although in the amniotes, estradiol and its ester are used interchangeably, in this species the two compounds produce diametrically opposed effects under the conditions of these experiments.

Literature Cited.

Allen, E., F. L. Hisaw and W. U. Gardner

1939. Endocrine Functions of the Ovaries. "Sex and Internal Secretions," Allen, Editor. Williams and Wilkin Baltimore.

Baldwin, F. M., and H. S. Goldin

1939. Effects of Testosterone Propionate the Female Viviparous Teleost *Xiphophorus hellerii* Heckel. *Proc. S Exp. Biol. and Med.*, Vol. 42, pp. 81 819.

Bellamy, A. W.

1928. Bionomic Studies on Teleosts, No. 2 Color Pattern Inheritance and Sex *Platypoecilus maculatus* (Günther *Genetics*, Vol. 13, pp. 226-232.

1933. Bionomic Studies on Teleosts, No. 4 Crossover and Nondisjunction. *Ge tics*, Vol. 18, pp. 531-534.

Berkowitz, P.

1937. Effects of Estrogenic Substances *Lebistes reticulatus. Proc. Soc. Ex Biol. and Med.*, Vol. 36, pp. 416-418.

1938. Effects of Estrogenic Substances *Lebistes reticulatus. Anatomical Re* Vol. 71, pp. 161-175.

1941a. Response of Fish (*Lebistes reticul tus*) to Mammalian Gonadotrophin *Journ. Exp. Zool.*, Vol. 86, pp. 247-25

1941b. Effects of Estrogenic Substances Fish (*Lebistes reticulatus*). *Jour Exp. Zool.*, Vol. 87, pp. 233-243.

Biskind, M. S.

1946. Nutritional Therapy of Endocrine Di turbances. Vitamins and Hormone Vol. 4, pp. 147-185.

Biskind, G. R., and L. Mark

1939. The Inactivation of Testosterone Pr pionate and Estrone in Rats. *Bu Johns Hopkins Hosp.*, Vol. 65, pp. 21 217.

Biskind, M. S., and G. R. Biskind

1941. Diminution in the Ability of the Liv to Inactivate Estrone in Vitamin Complex Deficiency. *Science*, Vol. p. 462.

1942. Effect of Vitamin B Complex Defi ency on Inactivation of Estrone in t Liver. *Endocrinology*, Vol. 31, pp. 10 115.

1943. Inactivation of Testosterone Propio ate in Liver during Vitamin B Compl Deficiency. Alteration of Estroge Androgen Equilibrium. *Endocrinolo* Vol. 32, pp. 97-102.

Blacher, L. J.

1926. The Dependence of Secondary S Characters upon Testicular Hormo in *Lebistes reticulatus. Biol. Bull.*, V 50, pp. 374-381.

Breider, H.

1942. ZW Maennchen und WW Weibchen *Platypoecilus maculatus. Biol. Ze tralbl.*, Vol. 62, pp. 187-195.

URRILL, M. W., AND R. R. GREENE
1942. Effects of Rat's Liver on the Activity of Testosterone and Methyl Testosterone. *Endocrinology*, Vol. 31, pp. 73-77.

ANTAROW, A., K. E. PASCHKIS, A. E. RAKOFF AND L. P. HANSEN
1943. Studies on Inactivation of Estradiol by the Liver. *Endocrinology*, Vol. 33, pp. 309-316.

OHEN, H.
1942. Effects of Estrogens and Androgens on *Platypoecilus maculatus*. Master's Thesis, New York University.
1946. Effects of Estrogens and Androgens on *Platypoecilus maculatus*. *Zoologica*, Vol. 31, pp. 121-128.

OHEN, H., M. GORDON AND R. F. NIGRELLI
1941. Spontaneous development of gonopods in females of *Platypoecilus maculatus*. *Anat. Rec.*, Vol. 81, (Suppl.), p. 89.

ORNER, G. W.
1942. Corpus Luteum Hormone. In Glandular Physiology and Therapy. pp. 185-196. American Medical Association, Chicago.

SSENBERG, J. M.
1923. Sex Differentiation in the Viviparous Teleost *Xiphophorus hellerii* Heckel. *Biol. Bull.*, Vol. 45, pp. 46-96.
1926. Complete Sex Reversal in the Viviparous Teleost *Xiphophorus hellerii*. *Biol. Bull.*, Vol. 51, pp. 98-111.

VERSOLE, W. J.
1939. The Effects of Androgens upon the Fish *Lebistes reticulatus*. *Endocrinology*, Vol. 25, pp. 328-330.
1941. Effects of Pregneninolone and Related Steroids on Sexual Development in Fish (*Lebistes reticulatus*). *Endocrinology*, Vol. 28, pp. 603-610.

RASER, A. C., AND M. GORDON
1929. The Genetics of *Platypoecilus*. II. The Linkage of the Two Sex-linked Characters. *Genetics*, Vol. 14, pp. 160-179.

REED, S. C.
1942. Present Status of Commercial Endocrine Preparations. In Glandular Physiology and Therapy. pp. 537-558. American Medical Association, Chicago.
1943. Practical Aspects of Endocrine Therapy. *West. Journ. Surg.*, Vol. 51, pp. 407-411.

OODRICH, H. B., J. E. DEE, C. M. FLYNN AND R. N. MERCER
1934. Germ Cells and Sex Differentiation in *Lebistes reticulatus*. *Biol. Bull.*, Vol. 67, pp. 83-96.

ORDON, M.
1927. The Genetics of a Viviparous Topminnow *Platypoecilus;* the Inheritance of two Kinds of Melanophores. *Genetics*, Vol. 12, pp. 253-283.
1931. Hereditary Basis for Melanosis in Hybrid Fishes. *Amer. Journ. Cancer*, Vol. 15, pp. 1495-1523.
1937a. Genetics of *Platypoecilus*. III. Inheritance of Sex and Crossing Over of the Sex Chromosomes in the Platyfish. *Genetics*, Vol. 22, pp. 376-392.
1937b. The Production of Spontaneous Melanotic Neoplasms in Fishes. II. Neoplasms with Macromelanophores Only. III. Neoplasms in Day Old Fishes. *Amer. Journ. Cancer*, Vol. 30, pp. 362-375.
1943. Feeding Platyfishes and Swordtails. *The Aquarium*, Vol. 12, pp. 86-88.
1946. Interchanging Genetic Mechanisms for Sex-determination in Fishes under Domestication. *Journ. Heredity*, Vol. 37, pp. 307-320.
1947a. Genetics of *Platypoecilus maculatus*. IV. The Sex Determining Mechanisms in Two Wild Populations of the Mexican Platyfish. *Genetics*, Vol. 32, pp. 8-17.
1947b. Speciation in Fishes. Distribution in Time and Space of Seven Dominant Multiple Alleles in *Platypoecilus maculatus*. Adv. Genetics, Vol. 1, pp. 95-132.
1948a. Effects of Five Primary Genes on the Site of Melanosis in Fishes and the Influence of Two Color Genes on their Pigmentation. In "The Biology of Melanomas," New York Acad. Spec. Pub., Vol. 4, pp. 216-268.
1948b. Personal Communication.

GORDON, M., AND F. FLATHMAN
1943. The Genetics of Melanoma in Fishes. VI. Mendelian Segregation of Melanophore Reaction in Embryos of a Melanomatous Mother. *Zoologica*, Vol. 28, pp. 9-12.

GROBSTEIN, C.
1940. Endocrine and Developmental Studies of Gonopodium Differentiation in Certain Poeciliid Fishes. I. The Structure and Development of the Gonopodium in *Platypoecilus maculatus*. *Univ. of Cal. Pub. in Zool.*, Vol. 47, pp. 1-22.
1942a. Effect of Various Androgens on Regenerating Anal Fin of Adult *Platypoecilus maculatus* Females. *Proc. Soc. Exp. Biol. and Med.*, Vol. 49, pp. 477-478.
1942b. Endocrine and Developmental Studies of Gonopodium Differentiation in Certain Poeciliid Fishes. II. Effect of Testosterone Propionate in Normal and Regenerating Anal Fin of Adult *Platypoecilus maculatus* Females. *Journ. Exp. Zool.*, Vol. 89, pp. 305-328.

HELLER, C. G.
1940. Metabolism of the Estrogens. *Endocrinology*, Vol. 26, pp. 619-630.

ISRAEL, S. L., D. R. MERANZE AND C. G. JOHNSTON
1937. The Inactivation of Estrogens by the Liver. Observations on the Fate of Estrogen in Heart Lung, and Heart Lung Liver Perfusion Systems. *Amer. Journ. Med. Sci.*, Vol. 194, pp. 835-843.

LEVINE, M., AND M. GORDON
1946. Ocular Tumors with Exophthalmia in Xiphophorin Fishes. *Cancer Res.*, Vol. 6, pp. 197-204.

MacBryde, C. M., D. Castrodale, E. B. Helwig and O. Bierbaum
1942. Hepatic Changes Produced by Estrone, Estradiol, and Diethylstilbestrol. *Journ. Amer. Med. Assn.*, Vol. 118, pp. 1278-1281.

Matthews, S. A.
1939a. Gonadal Stimulation in Sexually Immature *Fundulus* by Implantation of Adult Hypophysis. *Anatomical Rec.*, Vol. 75, Suppl. 1, p. 55.
1939b. The Relationship between the Pituitary Gland and the Gonads in *Fundulus*. *Biol. Bull.*, Vol. 76, pp. 241-250.

Nelson, W. O.
1937. Some Factors Involved in the Control of the Gametogenic and Endocrine Functions of the Testis. Cold Spring Harbor Symposia on Quantitative Biology, Vol. 5, pp. 123-135.

Regnier, M. T.
1938. Contribution à l'étude de la sexualité des cyprinodont vivipares (*Xiphophorus hellerii, Lebistes reticulatus*). *Biol. Bull. de la France et de la Belgique*, Vol. 72, pp. 385-493.

Rugh, R.
1935. Pituitary Induced Sexual Reactions in the Anura. *Biol. Bull.*, Vol. 68, pp. 74-81.

Scheer, B. T.
1948. Comparative Physiology. Chapter 10, pp. 517-530. Wiley and Sons Inc., New York.

Segaloff, A.
1943. The Intrasplenic Injection of Estrogens and Their Esters. *Endocrinology*, Vol. 33, pp. 209-216.

Scott, J. L.
1941. Effect of Steroid Hormones upon the Skeleton of *Lebistes reticulatus*. *Anatomical Rec.*, Vol. 81, suppl. 1, p. 90.
1944. Effect of Steroids on the Skeleton of the Poeciliid Fish *Lebistes reticulatus*. *Zoologica*, Vol. 29, pp. 49-53.

Simpson, G., and A. Roe
1939. Quantitative Zoology. McGraw Hill, New York.

Talbot, N. B.
1939. The Inactivation of Endogenous Estrogen by the Liver. *Endocrinology*, Vol. 25, pp. 601-604.

Tavolga, W. N., and R. Rugh
1947. Development of the Platyfish, *Platypoecilus maculatus*. *Zoologica*, Vol. 3 pp. 1-15.

Teague, R. S.
1941. Effect of Estrogens on the Microscop Appearance of the Liver. *Journ. Ame Med. Assn.*, Vol. 117, pp. 1242-1243.

Turner, C. L.
1941a. Gonopodial Characters Produced i Anal Fins of Females of *Gambus affinis affinis* by Treatment wit Ethinyl Testosterone. *Biol. Bull.*, Vo 80, pp. 371-383.
1941b. Regeneration of the Gonopodium *Gambusia* During Morphogenesi *Journ. Exp. Zool.*, Vol. 87, pp. 181-20
1941c. Morphogenesis of the Gonopodium *Gambusia affinis affinis*. *Journ. Morph* Vol. 69, pp. 161-185.

van Oordt, G. J., and C. J. J. van der Maas
1926. Castration and Implantation of Gonad in *Xiphophorus helleri* Heckel. Ko inklije Akad. von Wetenschappen Amsterdam, *Proc. Sect. Sci.*, Vol. 2 pp. 1172-1175.

Westerfeld, W. N.
1940. The Inactivation of Oestrone. *Biochem Journ.*, Vol. 29, pp. 51-58.

Willier, B. H.
1939. The Embryonic Development of Se In "Sex and Internal Secretions." Allen, Editor. Williams and Wilkin Baltimore.

Winge, Ö.
1934. Experimental Alteration of Sex Chro mosomes into Autosomes and Vic Versa as Illustrated by *Lebiste* Compt. Rend. d. trav. den Lab. Carls berg Serie. Physiol., Vol. 21, pp. 1-4

Witschi, E.
1939. Modification of Development of Sex i Lower Vertebrates and in Mammals In "Sex and Internal Secretions." Allen, Editor. Williams and Wilkins Baltimore.

Wolf, L. E.
1931. History of the Germ Cells in the Vivi parous Teleost *Platypoecilus macu latus*. *Journ. Morph. and Physiol.*, Vo 52, pp. 115-153.

EXPLANATION OF THE PLATES.

PLATE I.

Fig. 1. Testis of control male eight weeks of age. ×100.

Fig. 2. Testis of estradiol benzoate-treated male eight weeks of age. ×100.

Fig. 3. Testis of pregneninolone-treated male eight weeks of age. ×100.

Fig. 4. Testis of estradiol-treated male eight weeks of age. ×100. Compare with Fig. 3.

Fig. 5. Testis of estradiol-treated male eight weeks of age. ×100. Compare with Figs. 3 and 4.

PLATE II.

Fig. 6. Ovary of control female eight weeks of age. ×100.

Fig. 7. Ovary of estradiol benzoate-treated female eight weeks of age. ×100.

Fig. 8. Ovary of pregneninolone-treated female eight weeks of age. ×100.

Fig. 9. Ovary of pregneninolone-treated female eight weeks of age. ×100. Note scattering.

Fig. 10. Ovary of pregneninolone-treated female eight weeks of age. ×100. Note bilobed appearance of organ.

Fig. 11. Ovary of estradiol-treated female eight weeks of age. ×100. Compare with Fig. 9.

PLATE III.

Fig. 12. Ovary of estradiol-treated female eight weeks of age. ×100. Note large degenerating eggs and small abnormal eggs.

Fig. 13. Anal fin of control male. ×34.

Fig. 14. Anal fin of estradiol benzoate-treated male. ×34. Compare with Fig. 13.

Fig. 15. Anal fin of pregneninolone-treated male. ×34. Note almost complete differentiation of gonopodium. Compare with Fig. 13.

Fig. 16. Anal fin of estradiol-treated male. ×34. Compare with Figs. 13 and 15.

PLATE IV.

Fig. 17. Anal fin of control female. ×34.

Fig. 18. Anal fin of estradiol benzoate-treated female. ×34. Compare with Fig.17.

Fig. 19. Anal fin of pregneninolone-treated female. ×34. Compare with Figs. 15 and 17.

Fig. 20. Anal fin of estradiol-treated female. ×34. Compare with Figs. 16, 17 and 19.

PLATE V.

Fig. 21. Liver of control animal. ×960.

Fig. 22. Liver of estradiol benzoate-treated animal. ×960. Note similarity to Fig. 21.

Fig. 23. Liver of pregneninolone-treated animal. ×960. Note extensive vacuolization. Compare with Fig. 21.

Fig. 24. Liver of estradiol-treated animal. ×960. Note vacuolization—approaching but not equalling that of Fig. 23.

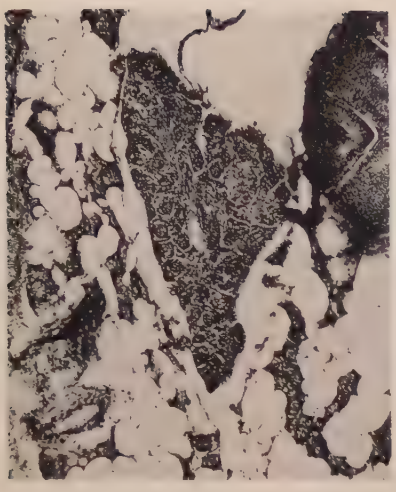


FIG. 1.

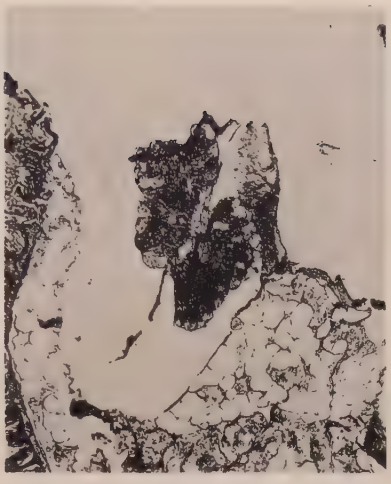


FIG. 2.

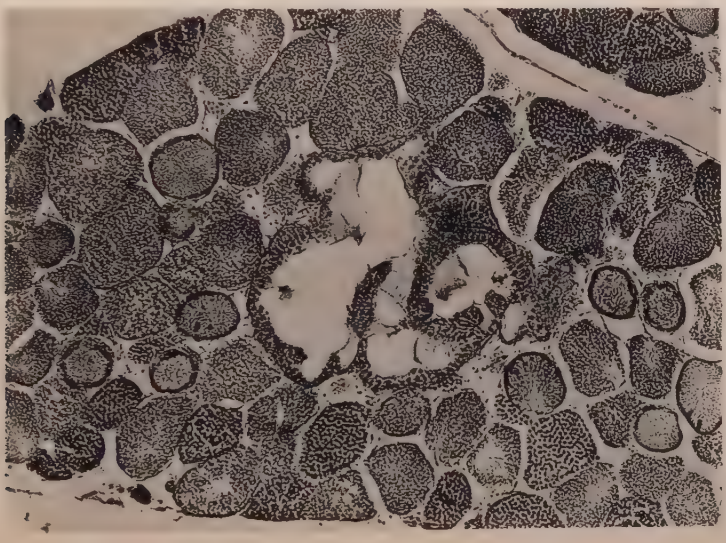


FIG. 3.

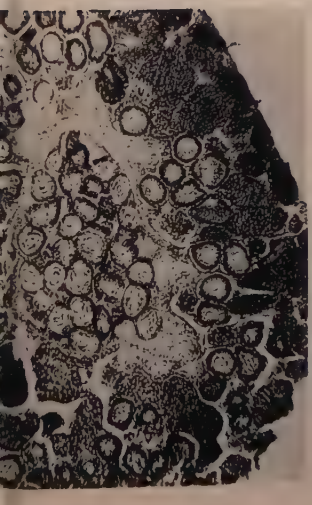


FIG. 4.

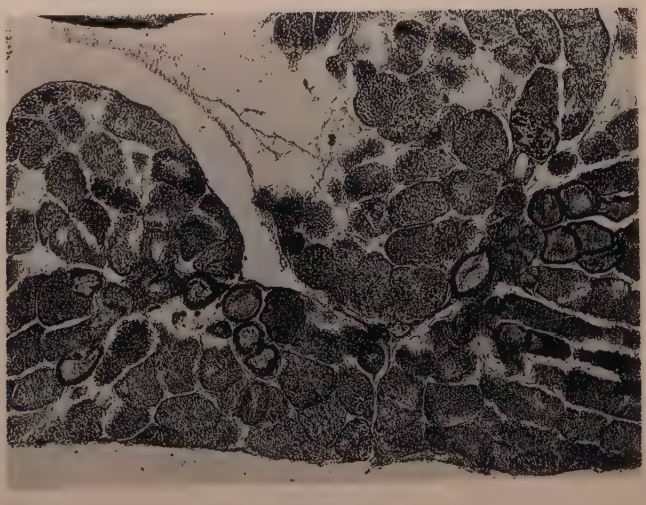


FIG. 5.

DIFFERENTIAL EFFECTS OF ESTRADIOL, ESTRADIOL BENZOATE AND PREGNENINOLONE ON PLATYPOECILUS MACULATUS.

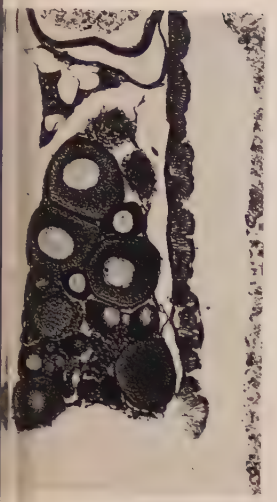


FIG. 6.

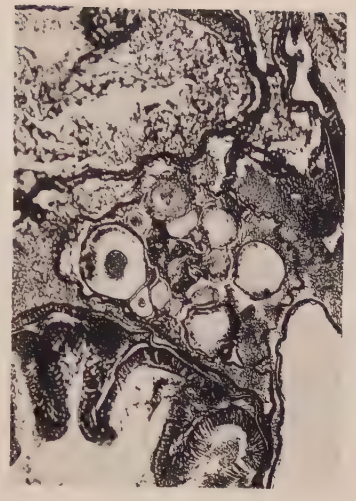


FIG. 7.

FIG. 8.

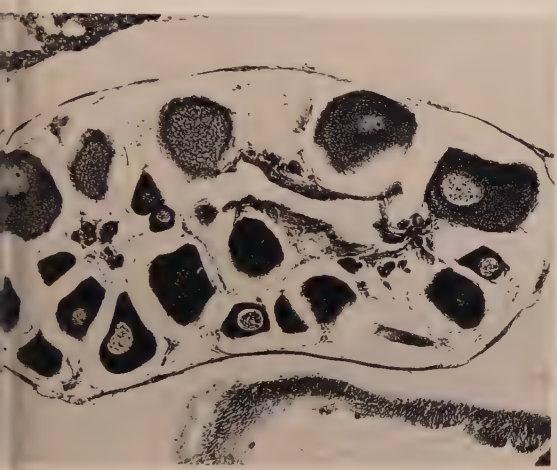


FIG. 9.

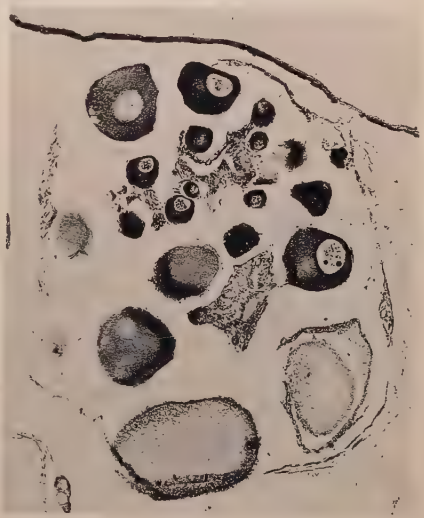


FIG. 11.

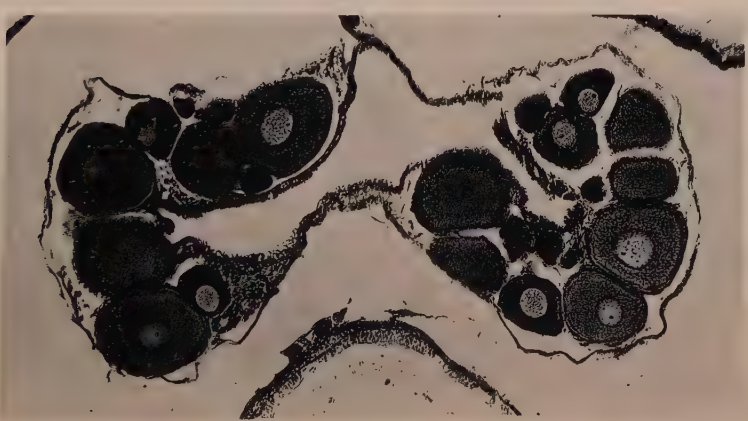


FIG. 10.

DIFFERENTIAL EFFECTS OF ESTRADIOL, ESTRADIOL BENZOATE AND PREGNENINOLONE ON PLATYPOECILUS MACULATUS.

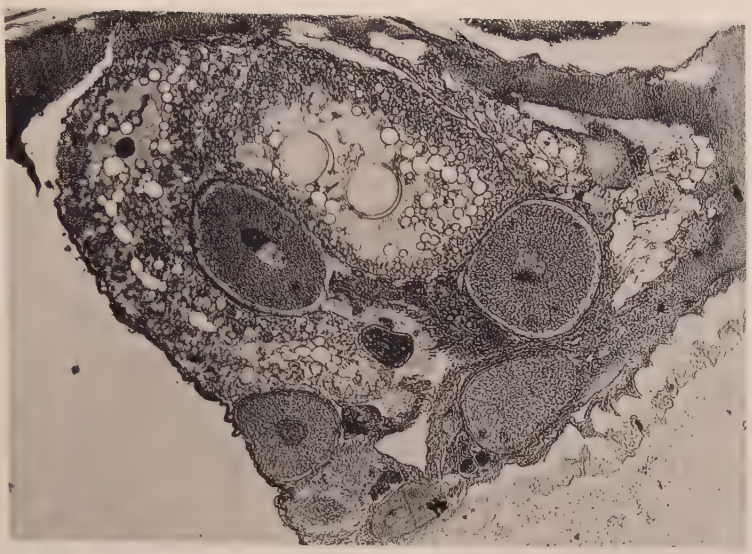


FIG. 12.

FIG. 13.

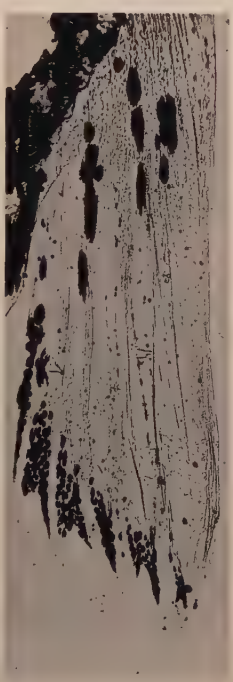


FIG. 14.

FIG. 15.

FIG. 16.

DIFFERENTIAL EFFECTS OF ESTRADIOL, ESTRADIOL BENZOATE AND PREGNENINOLONE ON PLATYPOECILUS MACULATUS.

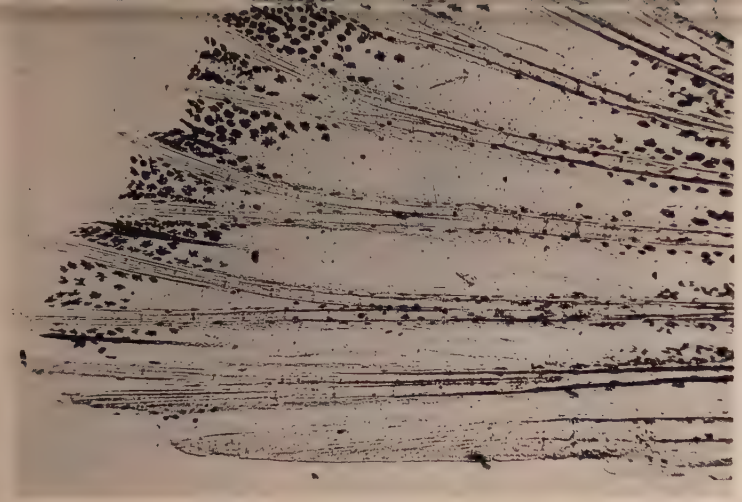


FIG. 17.

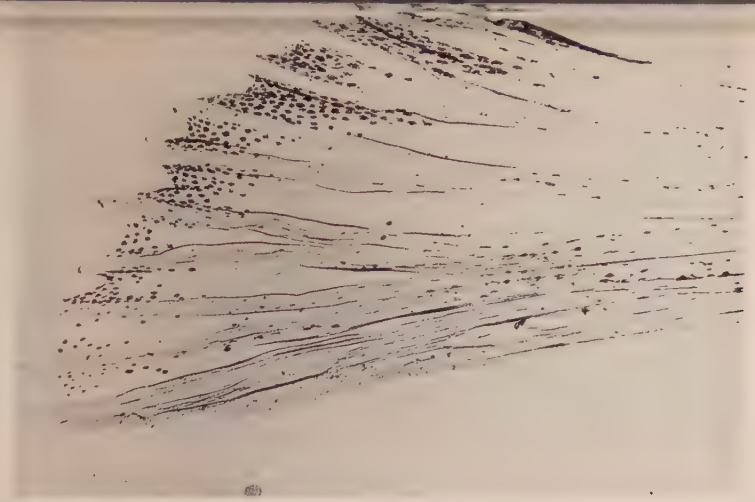


FIG. 18.

FIG. 19.

FIG. 20.

DIFFERENTIAL EFFECTS OF ESTRADIOL, ESTRADIOL BENZOATE AND PREGNENINOLONE ON PLATYPOECILUS MACULATUS.

FIG. 21.

FIG. 22.

FIG. 23.

FIG. 24.

DIFFERENTIAL EFFECTS OF ESTRADIOL, ESTRADIOL BENZOATE AND PREGNENINOLONE ON PLATYPOECILUS MACULATUS.

bb. Interior brown, orange or yellow
c. Interior brown; corrugated *tabogensis*
cc. Interior yellow or orange; wrinkle-ribbed exteriorly *californica*
aa. Exterior without radial sculpture *craneana*
B. Concentrically sculptured with raised threads, lamellae, or growth lines only
a. Concentric sculpture of growth lines only
b. Diagonal striae present *sparsilineata*
bb. Diagonal striae absent; smooth, pure white *laevis*
aa. Concentric sculpture of raised threads or lamellae
c. Escutcheon wide, strongly beveled *flavescens*
cc. Escutcheon very narrow or lacking
d. Shell without radial sculpture; white
e. Interspaces with fine concentric striae *paziana*[5]
ee. Interspaces without fine concentric striae *simplicissima*
dd. Shell with radial sculpture
f. Shell with incised radial grooves on part or all of valves
g. Incised sculpture along anterior dorsal margin only
h. Concentric ribs closely spaced, fine
i. Shell thick, fairly high; interior with a deep purple blotch *pulchra*
ii. Shell thinner, more elongate; less purple coloration *quentinensis*
hh. Concentric ribs more widely spaced, coarse *guaymasensis*
gg. Incised sculpture present along anterior and posterior margins
j. Concentric ribbing fine *jaramija*
jj. Concentric ribbing coarse; entire valv often reticu lately sculp tured *pacific*
ff. Shell without incised r dial grooves; fine radi striae present, stronge in interspaces
k. Shell suborbicula or roundly ovate
l. brownish - re with white m dial streak o umbos; large *jov*
ll. Yellowish white *mediamerican*
kk. Shell elongate
m. Concentric l mellae high shell large white with pu ple spots
n. Lamella with sca loped scale like projec tions *verrucos*
nn. Lamella without scale-lik projec tions; mo rounde ventrally *formos*
mm. Concentric l mellae low shell small umbos pu plish o brownish
o. Thick end o pallia sinu slightl atten uated *venust*
oo. Thin end o pallia sinu blunt *incon gru*

Semele corrugata californica Reeve.

Amphidesma californica Reeve, Conch Icon., Vol. 8, *Amphidesma*, October, 185 species 19, pl. 3, fig. 19. "Gulf of California.

[5] Not represented in the present collection.

Semele californica A. Adams, *Proc. Zool. Soc. London* for 1853 (issued July 25, 1854), p. 96. "Hab. Gulf of California. Mus. Cuming."

Type Locality: Gulf of California.

Range: Magdalena Bay, Lower California, to the Gulf of California.

Collecting Station: Mexico: Cape San Lucas, Lower California, beach.

Description: Shell ovately oblong, subequilateral, dirty pale brown, radiately striated; transversely sulcated, ribs elevated, subcorrugated, ornamented, interspaces closely longitudinally striated; anterior side rounded, posterior subtruncated, very flexuous; interior yellowish, margin yellow. (Free translation of Adams' original description.)

The shell of this subspecies is characterized by the concentric wrinkle-ridged ribs and the dense minute radial striae. A small lunule is present but no appreciable escutcheon. Exteriorly the shells are usually yellowish or yellowish-white in color. The umbos are often yellow and on some specimens a few faint brown transverse markings are present on the dorsal margin both anterior to and posterior to the beaks. Interiorly the shells are usually yellow, sometimes a beautiful golden or orange-yellow. The pallial sinus ascends gently and is rounded at the end which extends forward a little over one-half the length of the shell.

A left valve from Cape San Lucas, in the present collection, measures: length, 40.2 mm.; height, 36 mm.; convexity (one valve), 7.3 mm. A specimen from Magdalena Bay, Lower California, in the Henry Hemphill Collection of the California Academy of Sciences measures: length, 37.5 mm.; height, 33.6 mm.; convexity (both valves together), 15.2 mm.; pallial sinus extends anteriorly 22 mm. from the posterior margin of the shell.

This form apparently is, as stated by Dall, closely related to *Semele corrugata* Sowerby[6]. The specimens which we have seen from Magdalena Bay and the Gulf of California appear to be a little smaller than those of *S. corrugata* Sowerby which was described from Peru. Furthermore these do not have the purple coloration on the anterior portion of the hinge as shown on Reeve's illustration of *Semele corrugata*. That species has been recorded as occurring at Magdalena Bay and in the Gulf of California, and it is possible that the present specimen might be referable to Sowerby's species. However, for the present at least, we are inclined to regard these northern shells as belonging to a subspecies of *S. corrugata*, at least until a comparison can be made with a series of specimens from Peru, the type locality of Sowerby's species.

It appears that in some cases, *Semele corrugata californica* has been confused with *Semele flavescens* Gould, a different shell.

Distribution: A single valve of this subspecies was taken by the expedition on the beach at Cape San Lucas. It also occurs in the Pleistocene of Magdalena Bay, Lower California. The record "*Semele* cf. *pulchra* Sowerby" in the list of species cited by Jordan, 1936, as occurring in the Pleistocene of Magdalena Bay, is referable to *S. corrugata californica*. Olsson has recorded "*Semele* cf. *californica* Con." as occurring in the Pleistocene of Panama. Records of the occurrence of this shell in Asiatic seas are referable to some other species.

Semele craneana Hertlein & Strong, sp. nov.

Plate I, Figs. 19, 22.

Shell oval, compressed, thin, with the beaks a little nearer the posterior end, yellowish, with faint, pinkish, interrupted radial stripes; posterior dorsal margin sloping, slightly convex, forming a distinct angle with the truncated posterior end, anterior dorsal margin more direct, slightly concave, anterior dorsal margin well rounded; lunule very small, indistinct; outer surface smooth near the beaks gradually developing concentric ridges which are strongest near the margins, with deep interspaces which about equal the ridges in width; posterior end with a depression running from near the beaks to the lower end of the truncation, posterior to which the shell is flattened and somewhat flexed; radial sculpture entirely absent; interior white, somewhat iridescent, showing the concentric sculpture and pinkish rays quite distinctly; pallial sinus broad, ascending, rounded at the end and projecting about two-thirds the length of the shell; two cardinal teeth, the posterior one the larger, lateral teeth small. The type measures: length, 38 mm.; height, 29.5 mm.; convexity (one valve), 6.5 mm.; pallial sinus projects forward 24 mm. from the posterior margin of the shell.

Holotype, a left valve, (Calif. Acad. Sci. Paleo. Type Coll.), dredged in the Gulf of California. One left valve was dredged on Arena Bank, Gulf of California, Station 136-D-24, Lat. 23°29′ N., Long. 109°23′30″ W., in 50 fathoms (91 meters), mud, *Arca* conglomerate; one young specimen and a single right valve were dredged in the same general locality, Station 136-D-26, Lat. 23°27′ N., Long.

---

6 *Amphidesma corrugatum* Sowerby, Conch. Illustr., Catal. issued with Pt. 19, species No. 8, issued between January 18 and March 8, 1833. [Not illustrated]. "Iquiqui, Peru. Mr. Cuming." Ref. to "Spec. Conch. f. 18." [The exact dates of issue of the Species Conchyliorum is unknown to us. A copy of Volume 1, Part 2, in the library of the California Academy of Sciences is not dated. In Hanley's edition of Wood's Index Testaceologicus, 1856, p. XIX, the dates cited for Sowerby Species Conchyliorum are, "part 1. 1830: part II. (imperfect) not published until Nov. 1855"]. —Sowerby, *Proc. Zool. Soc. London* for 1832, issued March 13, 1833, p. 200. "Hab. in Peruviâ et ad Iquiqui." "Dredged from coarse gravel in ten fathoms water."—Reeve, Conch. Icon., Vol. 8, *Amphidesma*, October, 1853, species 4, pl. 1, fig. 4 (as *Amphidesma corrugata*). [Locality same as in preceding reference].

Shaw (*Proc. Malacol. Soc. London*, Vol. 8, No. 6, 1909, pp. 333-340), in a collation of the Conchological Illustrations, indicated that Parts 17, 18, 19, and the catalogue of species of *Amphidesma* issued with Part 19, appeared between January 18 and March 8, 1833. The species of *Amphidesma* named and illustrated in those parts for the first time take their date of publication from the Conchological Illustrations rather than the *Proceedings* of the Zoological Society of London where the descriptions appeared on March 13, 1833.

109° 24′ W., in 45 fathoms (82 meters), sand, crushed shell; a single valve was dredged 3 miles off Pyramid Rock, Clarion Island, Station 163-D-2, Lat. 114° 45′ N., Long. 114° 45′ W., in 55 fathoms (100 meters), rock, coral.

This shell is similar in size and shape to *Semele tabogensis* Pilsbry & Lowe. The sculpture is similar but lacks the fine radial ornamentation of that species and the posterior area is more distinct.

The shell of *Semele craneana*, although less arcuate ventrally, is similar to that of *S. martinii* Reeve[7] which was originally described from Brazil.

This species is named for Miss Jocelyn Crane, Technical Associate, Department of Tropical Research, New York Zoological Society, who accompanied the Templeton Crocker Expedition, 1936, during the course of which the type specimen of the present species was collected.

Distribution: This new species is at present known only from the southern portion of the Gulf of California and from off Clarion Island, in 45-55 fathoms.

Semele decisa Conrad.

Amphidesma decisa Conrad, *Jour. Acad. Nat. Sci. Philadelphia*, Vol. 7, 1837, p. 239, pl. 19, fig. 2. "Inhabits with the preceding" [which is "Inhabits deep water in the vicinity of Sta. Diego".]—Reeve, Conch. Icon., Vol. 8, *Amphidesma*, 1853, species 24, pl. 4, fig. 24. San Diego, California.

Semele decisa Conrad, Grant & Gale, *Mem. San Diego Soc. Nat. Hist.*, Vol. 1, 1931, p. 376, pl. 14, figs. 13a, 13b. Earlier records cited. Pleistocene and Recent.

Type Locality: San Diego, California, in deep water.

Range: San Pedro, California, to Cape San Lucas, Lower California.

Collecting Station: Mexico: Cape San Lucas, Lower California.

Description: Shell rounded, thick, subequilateral, the anterior side the longer, the end rounded; posterior dorsal margin nearly straight, the posterior end truncated; posteriorly biangulate, the area between somewhat concave; ornamented with numerous, thick, unequal concentric rugose ribs, the entire surface covered with fine radial grooves or fine wrinkled and granulated sculpture; colored exteriorly by whitish-gray with occasional purple in the concentric grooves; cardinal teeth obsolete, laterals present; pallial sinus wide, rounded at the end, slightly ascending and extending forward about five-eighths the length of the shell which is past a line vertical with the beaks; interior white with purple around the dorsal margin.

A specimen from Cape San Lucas, Lower California, measures: length, 45 mm.; height, 42.5 mm.; convexity (both valves together), 19.8 mm.; pallial sinus extends anteriorly 27 mm. from the posterior margin of the shell. A large specimen of this species from Magdalena Bay, Lower California, in the Henry Hemphill collection of the California Academy of Sciences measures length, 94 mm.; height, 86.5 mm.; convexity (both valves together), 45.5 mm.; pallial sinus extends anteriorly 59 mm. from the posterior margin of the shell.

The shell of *Semele punctata* Sowerby[8] which was described from the Galápagos Islands, is more elongate in outline and less truncated posteriorly than that of *S. decisa*.

Semele nisigotoensis Nomura & Hatai[9], described from the Miocene of Japan, was compared to *S. decisa*.

Distribution: A few specimens of this species were collected by the expedition at Cape San Lucas, Lower California. This is an extension south of the known range of the species. It also has been recorded as occurring in the Pleistocene of Tomales Bay in Central California, in southern California, and south to Magdalena Bay, Lower California.

Semele flavescens Gould.

Amphidesma flavescens Gould, *Proc. Boston Soc. Nat. Hist.*, Vol. 4, November, 1851, p. 89. "San Diego, Lieut. Green."—Gould, *Boston Jour. Nat. Hist.*, Vol. 6, 1853, p. 392. Original locality cited.

Amphidesma proximum C. B. Adams, *Ann. Lyceum Nat. Hist. New York*, Vol. 5, July 1852, pp. 513, 547 (separate, pp. 289, 323). "Habitat. — Panama." — Hanley, Cat. Rec. Bivalve Shells, p. 341, 1856, pl. 12, fig. 5, 184[illegible] (cited as *Amphidesma corrugatum* on expl. to plate). "Mexico."

Amphidesma proxima Adams, Reeve, Conch. Icon., Vol. 8, *Amphidesma*, 1853, species 20, pl. 3, fig. 20. "Hab. Panama." [A reproduction of this figure given by M. Smith, Panamic Mar. Shells (Tropical Photogr. Lab., Winter Park, Florida), 1944, fig. 805].

Semele flavescens Gould, Lamy, *Journ. de Conchyl.*, Vol. 61, No. 3, 1914, p. 358. Gulf of California; Panama.

Semele proxima C. B. Adams, Olsson, *Nautilus*, Vol. 37, No. 4, 1924, p. 129. Zorritos, Lobitos, Negritos, Peru.

Type Locality: San Diego, California.

Range: Catalina Island, California (Dall) to Negritos, Peru.

Collecting Station: Costa Rica: Golfito Bay, Gulf of Dulce.

Description: Shell subrotund, compressed, sculptured by concentric lamellar decussate striae, orange becoming white in later stages and covered with a periostracum which is

---

[7] *Amphidesma martinii* Reeve, Conch. Icon., Vol. 8, *Amphidesma*, November, 1853, species 43, pl. 6, fig. 43. "Hab. Rio." [A. Adams' description of this species did not appear until July 25, 1854].

[8] *Amphidesma punctatum* Sowerby, Conch. Illustr. *Amphidesma*, Catal. issued with Pt. 19, No. 18, pl. 18, fig. 7 issued between January 18 and March 8, 1833. "Galapago Islands. Mr. Cuming."—Sowerby, *Proc. Zool. Soc. London* for 1832 (issued March 13, 1833), p. 200. "Hab ad Insula Gallapagos."—Reeve, Conch. Icon., Vol. 8, *Amphidesma*, October, 1853, species 26, pl. 4, fig. 26 (as *Amphidesma punctata*). Galápagos Islands.

[9] *Semele nisigotoensis* Nomura & Hatai, *Saito Ho-On Kai Mus. Res. Bull.*, No. 10, 1936, p. 131, pl. 16, figs. 8, 9. Nisigôto. Tanagura Beds, northwest Honsyu, Japan, middle Miocene.

brown shaded with gray (fusco); beaks median, acute, not at all elevated; anterior dorsal area excavated, posterior lanceolate, concave bounded by a line; interior tinted yellow, marked with shiny dots; pallial sinus spatulate, sculptured by close divergent striae; ligamental pit deep, elongate; anterior lateral teeth approximate to the beaks. Long. 2⅜; alt. 2⅛; lat. 1¼ poll. (Translation of Gould's original description).

"Usually found about half the above size; the concentric lamellae become worn off and more irregular towards the margin. The interior is faintly tinted yellow when young, but very richly so when old. It is near *A. corrugatum*, Sowb."

The description given by Gould in 1853 is an enlargement of the original. He stated: . . . "posterior dorsal edge long lanceolate, concave, bounded by a distinct angle; surface pale orange near the beaks, becoming dingy white at the older stages, and covered by a dirty greenish epidermis; marked by concentric lamellar striae, crossed by fine radiating striae, especially across the disk."

A left valve in the present collection measures: length, 47.5 mm.; height, 43.8 mm.; convexity (one valve), 11.2 mm. A specimen from Loreto, Lower California, in the collections of the California Academy of Sciences measures: length, 58.5 mm.; height, 55.4 mm.; convexity (both valves together), 28.3 mm.; pallial sinus extends forward 36 mm. from the posterior margin. A large single left valve from Magdalena Bay, Lower California, in the collection of the same institution measures: length, 64.4 mm.; height, 63.4 mm.; convexity (one valve), 15 mm.; pallial sinus extends anteriorly 40 mm. from the posterior margin of the shell.

Gould's type specimen has never been illustrated but the foregoing description applies exactly to specimens of a species in the collection of the California Academy of Sciences which were collected from Lower California to Panama. This species is identical with the one illustrated by Reeve under the name of *Amphidesma proxima* Adams. According to Dall[10] Adams' species is identical with *Semele flavescens*. *Amphidesma proximum* C. B. Adams was founded upon a specimen from Panama 1.8 inches in length. It was said to be closely related to *Semele elliptica* Sowerby and *S. lenticulare* Sowerby. Carpenter[11] regarded *S. proxima* as identical with *S. elliptica*. Whether or not *S. proxima* is identical with *S. flavescens* may be open to doubt but certainly Reeve's figure attributed to that species is referable to *S. flavescens*.

In some cases *Semele flavescens* has been identified under the name of *Semele striosa* C. B. Adams[12]. That species was based upon a single specimen from Panama .78 inch in length and it appears uncertain exactly how it differs from related forms. In the original description it is mentioned . . . "corselet and lunule not well defined." This does not agree with *S. flavescens* which has a well developed escutcheon.

Semele mediamericana Pilsbry & Lowe[13] differs from *S. flavescens* in lacking the strong escutcheon and in the sculpture in which . . . "there are narrow, thread-like concentric ridges, coarser and more raised than in *S. flavescens*, a little less than one mm. apart on the lower part of the valve, and a very minute, dense, even radial sculpture throughout, diverging at both ends, and seen under the lens to be totally unlike the radial striation of *S. flavescens*."

Distribution: A single left valve of *Semele flavescens* was taken by the expedition at Golfito Bay in the Gulf of Dulce. It occurs fairly commonly from Magdalena Bay to the Gulf of California and south to Panama and apparently to Peru. We have not seen specimens from north of Magdalena Bay, but the type locality is San Diego, and Dall cited it as occurring north to Catalina Island. It also occurs in the Pliocene of the Gulf of California region and in the Pleistocene of Magdalena Bay, Lower California, and it has been recorded as occurring in the Quaternary of Ecuador. Olsson, 1932, cited "*Semele* cf. *flavescens* Gould" as occurring in the Miocene of Peru.

Semele guaymasensis Pilsbry & Lowe.

Semele guaymasensis Pilsbry & Lowe, *Proc. Acad. Nat. Sci. Philadelphia*, Vol. 84, May 21, 1932, p. 92, pl. 12, figs. 8 and 9. "Guaymas, 20 fathoms."—E. K. Jordan, *Contrib. Dept. Geol. Stanford Univ.*, Vol. 1, No. 4, 1936, p. 145. Magdalena Bay, Lower California, Pleistocene. Also Gulf of California, Recent.

Type Locality: Guaymas, Sonora, Mexico, in 20 fathoms.

Range: Punta Penasco, Sonora, Mexico, to La Paz, Lower California.

Collecting Station: Mexico: Santa Inez Bay, Gulf of California (145-D-1, 3), 4-13 fathoms, sand.

Description: The shell is light buff, faintly mottled or obscurely rayed with dull light purple, the dorsal borders dark purple. Shape irregularly oval, nearly equilateral, strongly compressed; dorsal margin slightly convex behind, straight in front of the beaks; ends rounded; ventral margin strongly convex. Sculpture of strong, concentric ridges generally a little wider than their intervals, a little lamellar at the border of the escutcheon, and on the anterior end cut by about seven radial grooves. Escutcheon very narrow, flattened, with weak growth lines only, purple. Lunule small, sunken, the dorsal area beyond it pur-

[10] Dall, W. H., *Proc. Acad. Nat. Sci. Philadelphia*, Vol. 67, 1915, p. 25.

[11] Carpenter, P. P., *Proc. Zool. Soc. London*, 1863, p. 367. Reprint in *Smithson. Miscell. Coll.*, No. 252, 1872, p. 203.

[12] *Amphidesma striosum* C. B. Adams, *Ann. Lyceum Nat. Hist. New York*, Vol. 5, July, 1852, pp. 515, 547 (separate pp. 291, 323). "Habitat.—Panama."

[13] *Semele mediamericana* Pilsbry & Lowe, *Proc. Acad. Nat. Sci. Philadelphia*, Vol. 84, May 21, 1932, p. 92, pl. 12, figs. 1, 1a, 2 (as *Semele mediamericanum* on expl. to pl.). "Nicaragua (McNeil)."

ple and smooth except for lines of growth. The interior is stained with dull purple on a buff or white ground, with purple markings on the ventral border. The pallial sinus occupies about two-thirds of the length. Length, 16 mm.; height, 12.3 mm.; semidiam. (right valve), 2.6 mm. Length, 22 mm.; height 17 mm.; semidiam. (right valve) 4 mm. (Original description.)

This species differs from *Semele pulchra* Sowerby and *S. quentinensis* Dall in the much coarser and more widely spaced concentric sculpture.

Semele anteriocosta Vokes[14], described from the Miocene of Trinidad, is similar to *S. guaymasensis* in its general characters but the strength of the ribbing appears to be intermediate between that of this species and *S. quentinensis*.

Distribution: A few specimens referable to this species were dredged by the expedition in Santa Inez Bay, in the Gulf of California, in 4-13 fathoms, on a sandy bottom.

Semele jaramija Pilsbry & Olsson.

Plate I, Fig. 12.

Semele jaramija Pilsbry & Olsson, *Proc. Acad. Nat. Sci. Philadelphia,* Vol. 93, September 9, 1941, p. 70, pl. 17, fig. 5. "Canoa formation, Punta Blanca." Ecuador, Pliocene.

Type Locality: Canoa formation, Punta Blanca, Ecuador, Pliocene.

Range: Santa Inez Bay, Gulf of California.

Collecting Station: Mexico: Santa Inez Bay, Gulf of California (145), on shore.

Description: Shell small, suboval in form, with the beaks placed a little in back of the middle; but little convex; the sculpture consists of strong, regular, concentric threads, well developed over the whole shell and at the anterior-upper end, these concentric threads are cut by a series of small radial grooves; at the posterior end the grooves, about 8 in number, are crossed by the concentric threads, the sculpture being beautifully cancellated. Length, 21 mm.; height, 16 mm.; semidiameter, 3.5 mm. (Original description.)

A left valve of this species in the present collection measures: length, 16 mm.; height, 12.2 mm.; convexity (one valve), 2.9 mm.; pallial sinus extends anteriorly 9.5 mm. from the posterior margin of the shell.

The present specimen agrees exactly with the illustration of *Semele jaramija* given by Pilsbry & Olsson.

As mentioned in the discussion of *Semele pacifica,* that species always has radial sculpture on both the anterior and posterior dorsal areas. The variation in *S. pacifica* Dall is so great that it appears quite possible that the form here cited as *S. jaramija* may be merely a subspecies of it.

[14] *Semele anteriocosta* Vokes, *Amer. Mus. Novit.,* No. 988, May 16, 1938, p. 14, fig. 5. Upper Miocene of Springvale, Trinidad, British West Indies.

Semele guaymasensis Pilsbry & Lowe a
S. quentinensis Dall have radial sculptu
usually only on the anterior dorsal area a
when present at all posteriorly it is much le
strongly developed than that on *S. jaramij*

Distribution: A single left valve here r
ferred to *Semele jaramija* was taken by t
expedition on shore at Santa Inez Bay
the Gulf of California. This species has al
been recorded as occurring in the Pleistoce
of Panama and in the Pliocene at Pun
Blanca, Ecuador.

Semele jovis Reeve.

Amphidesma jovis Reeve, Conch. Icon
Vol. 8, *Amphidesma,* November, 1853, sp
cies 34, pl. 5, fig. 34. "Hab.—?"

Semele jovis A. Adams, *Proc. Zool. So
London* for 1853 (issued July 25, 1854),
94. "Hab. ? Mus. Cuming."

Tellina barbarae Boone, *Bull. Bingha
Oceanogr. Coll.* Peabody Mus. Yale Univ
Vol. 2, Art. 5, December, 1928, p. 9, pl.
(upper figure). "Pearl Islands, depth 1
fathoms."

Type Locality: Port Parker, Costa Ric
(here designated as type locality). No l
cality cited originally.

Range: Kino Bay, Sonora, Mexico, in th
Gulf of California, to the Las Perlas Island
Panama.

Collecting Stations: Mexico: Port Gua
tulco (195-D-2), 3 fathoms, sand; Nicara
gua: Corinto (200-D-19), 12-13 fathom
mangrove leaves; Costa Rica: Port Parke
(203-D-1-3), 12-15 fathoms, sandy muc
crushed shell, shelly sand, algae, shelly muc

Description: Shell somewhat roundl
ovate, somewhat ventricose, anterior sid
slightly the longer; posterior side with
flexure, the end truncated; ornamented wit
rather thin, close-set, concentric lamellae
the interspaces with fine concentric linea
tion; extremely fine radial wrinkling presen
on fresh specimens but clearly noticeable o
worn specimens; color rose-fawn, beaks re
with a medial white streak; hinge with tw
cardinals and laterals in each valve; pallia
sinus broadly elliptically rounded, projectin
forward about four-sevenths the length o
the shell; interior rose and white.

A right valve from Port Guatulco, Mexico
measures: length, 54.5 mm.; height, 45 mm.
convexity (one valve), 10.3 mm.; pallia
sinus extends anteriorly 32.5 mm. from th
posterior margin of the shell. A specime
collected by H. N. Lowe at Kino Bay, Sonora
Mexico, in the Gulf of California, measure
59 mm. in length.

Semele rosea Sowerby[15], described fro
Peru, is more orbicular in outline than S
jovis.

[15] *Amphidesma roseum* Sowerby, Conch. Illustr., Cata
issued with Pt. 19, species No. 5, pl. 17, fig. 1, issue
between January 18 and March 8, 1833. "Tumbez, Peru
Mr. Cuming."—Sowerby, *Proc. Zool. Soc. London* for 183
(issued March 13, 1833), p. 199. "Hab. ad littora Peruviae.
"A single valve was found at Tumbez in Peru."—Reev
Conch. Icon., Vol. 8, *Amphidesma,* October, 1853, specie
17, pl. 3, fig. 17 (as *Amphidesma rosea*). Tumbez, Peru

According to Verrill the lamellae are more closely spaced and the plication of *Semele jovis* is nearer the outer edge as compared to that of *S. junonia* Verrill[16] which was described from La Paz, Lower California. He mentioned the presence of radiating striae in the interspaces of *S. junonia*, a feature also present and especially noticeable on somewhat worn specimens of *S. jovis*. According to Lamy[17] *Semele junonia* is only a variety of *S. rosea*.

Distribution: A few single valves of *Semele jovis* were dredged by the expedition off western Mexico, Nicaragua, and Costa Rica.

Semele laevis Sowerby.

Amphidesma laeve Sowerby, Conch. Illustr., Catal. issued with Pt. 19, No. 22, pl. 18, fig. 6, issued between January 18 and March 8, 1833. "Xipixapi. W. Col. Mr. Cuming."—Sowerby, *Proc. Zool. Soc. London* for 1832 (issued March 13, 1833), p. 199. "Hab. ad Xipixapi, Columbiae Occidentalis." "A single specimen of this very delicate species was dredged from a depth of ten fathoms in sandy mud."

Amphidesma laevis Sowerby, Reeve, Conch. Icon., Vol. 8, *Amphidesma*, November, 1853, species 50, pl. 7, fig. 50. Original locality cited.

Type Locality: Xipixapi [Jipijapa], Ecuador, in 10 fathoms, sandy mud.

Range: Champerico, Guatemala, to Jipijapa, Ecuador.

Collecting Stations: Guatemala: 7 miles west of Champerico (197-D-1-2), 14 fathoms, mud; El Salvador: La Libertad (198-D-1-2), 13-14 fathoms, mud; Costa Rica: Gulf of Dulce.

Description: Shell elongately ovate, inequilateral, the anterior side the longer, smooth, exterior and interior white; anterior dorsal margin nearly straight, sloping, anterior end tapering and rounded; ventral margin curved; posterior dorsal margin rounded and highest just back of the beaks, posterior end rounded; a broad, shallow, radial groove is present on the posterior area and where this meets the ventral margin there is sometimes a vague truncation; surface smooth except for concentric lines of growth and an occasional concentric groove and sometimes with fine submicroscopic radial striae; hinge of right valve with two small cardinals, the posterior one bifid, the anterior one thin, two laterals present, left valve with two cardinals, the anterior one bifid, the posterior one thin, also projections of the margin which fit into corresponding sockets in the right valve; pallial sinus somewhat elevated above then broadly tapering to a rounded point which projects forward about five-eighths the length of the shell.

A large right valve from off La Libertad, El Salvador, measures approximately: length, 68 mm.; height, 53 mm.; convexity (one valve), 13 mm.; pallial sinus extends anteriorly 48.4 mm. from the posterior margin of the shell.

Semele laevis var. *costaricensis* Olsson[18] has been described from the Miocene of Costa Rica and later was cited as also occurring in the Miocene of Peru.

Semele pallida Sowerby[19], described from Ecuador, bears a resemblance, in general features, to *S. laevis* but differs in that it is less elongate anteriorly, less rounded posteriorly, the beaks are more anteriorly situated and the coloration was described as pale purple-fulvous.

Distribution: Specimens of this species were dredged off Guatemala and El Salvador in 13-14 fathoms and were taken on the beach of the Gulf of Dulce. These occurrences extend the known range of the species considerably to the north as heretofore it has not been reported north of Panama. This species also has been recorded as occurring in the Pleistocene of Panama and in the Pliocene at Puerto Jama, Ecuador.

Semele pacifica Dall.

Plate I, Fig. 11.

Semele pacifica Dall, *Proc. Acad. Nat. Sci. Philadelphia*, Vol. 61, March 2, 1915, p. 27. "Catalina Island, California, to Acapulco, Mexico, in 9 to 21 fathoms."—I. S. Oldroyd, *Stanford Univ. Publ. Univ. Ser. Geol. Sci.*, Vol. 1, 1924, p. 180, pl. 3, fig. 5. Original range cited.—J. Q. Burch, *Min. Conch. Club South. Calif.*, No. 43, January, 1945, p. 17. "Dr. A. M. Keen advises 'Type locality of *S. pacifica* is: U. S. B. F. Sta. 2022, off La Paz, in 21 fms.'"

Type Locality: Off La Paz, Lower California, in 21 fathoms (Keen).

Range: Catalina Island, California, to the Gulf of California and south to Taboga Island, Panama.

Collecting Stations: Mexico: Santa Inez Bay, Gulf of California (145-D-1, 3), 4-13 fathoms, sand, also on shore; Costa Rica: Port Parker (203-D-3), 12 fathoms, shelly mud; Golfito, Gulf of Dulce.

Description: The shell of this species is very similar to that of *Semele cancellata* Sowerby[20] which occurs in Atlantic waters.

---

16 *Semele junonia* Verrill, *Amer. Jour. Sci.*, Ser. 2, Vol. 9, No. 146, March, 1870, p. 217. "Near La Paz,— Capt. . Pedersen."

17 Lamy, E., *Journ. de Conchyl.*, Vol. 61, No. 3, 1914, . 357.

18 *Semele laevis* Sowerby, var. *costaricensis* Olsson, *Bull. Amer. Paleo.*, Vol. 9, Bull. 39, Pt. 2, June 21, 1922, p. 430 (258), pl. 32 (29), fig. 1. "Gatun Stage: Hill No. 3, Banana River." Costa Rica, Miocene.

19 *Amphidesma pallidum* Sowerby, Conch. Illustr., Catal. issued with Pt. 19, sp. No. 3, pl. 17, fig. 3, issued between January 18 and March 8, 1833. "Salango, W. Col. Mr. Cuming."—Sowerby, *Proc. Zool. Soc. London* for 1832 (issued March 13, 1833), p. 199. "Hab. ad Salango, Columbiae Occidentalis." "Dredged in sandy mud at a depth of seven fathoms."—Reeve, Conch. Icon., Vol. 8, *Amphidesma*, 1853, species 22, pl. 4, fig. 22 (as *Amphidesma pallida*). Original locality cited.

20 *Amphidesma cancellatum* Sowerby, Conch. Illustr., Catal. issued with Pt. 19, species No. 13, issued between January 18 and March 8, 1833. "Antigua and St. Vincents." Ref. to "Spec. Conch. f. 8."—Reeve, Conch. Icon., Vol. 8, *Aphidesma*, 1853, species 44, pl. 7, fig. 44 (as *Amphidesma cancellata*). "Hab.—?."

Dall stated in the original description that it . . . "differs from that Atlantic species in its smaller lunule, shorter and weaker right lateral tooth, and sharper and more delicate concentric sculpture."

A left valve in the present collection from Golfito, Gulf of Dulce, Costa Rica, measures: length, 20 mm.; height, 16.6 mm.; convexity (one valve), 4.6 mm.

Semele pacific is a very variable species. Young specimens have rather flattened shells and strong cancellate sculpture with the concentric lamellae well developed. In the adult stage the shells become thicker, more ventricose, and with the radial element in the sculpture as strong or stronger than the concentric. The radial sculpture is always present near the anterior and posterior dorsal margins and sometimes covers the whole shell.

Semele pacifica is one of a group of related species which vary in details of sculpture. *Semele venusta* Reeve has no radiating sculpture. *Semele guaymasensis* Pilsbry & Lowe has strong concentric sculpture but with incised radiating sculpture only on the anterior dorsal area. *Semele quentinensis* Dall has very fine concentric sculpture with radial sculpture on the anterior dorsal portion and, rarely, with a few faint striae along the posterior dorsal margin. *Semele pulchra* Sowerby has concentric and radial sculpture similar to that of *S. quentinensis* but the shell is higher in proportion to the length as compared to Dall's species. *Semele jaramija* Pilsbry & Olsson, described from the Pliocene of Ecuador, has concentric sculpture intermediate in strength between that of *S. quentinensis* and *S. guaymasensis*, but in addition to similar radial sculpture on the anterior dorsal area it also has strong, incised radial sculpture on the posterior dorsal area. *Semele pacifica* has strong well developed concentric sculpture with radials on both the anterior and posterior portions and sometimes all over the shell.

Distribution: A few specimens of *Semele pacifica* were dredged by the expedition in 4-13 fathoms in Santa Inez Bay, in the Gulf of California, at Port Parker, Costa Rica, in 12 fathoms, and at Golfito in the Gulf of Dulce.

***Semele pulchra* Sowerby.**

Plate I, Fig. 15.

Amphidesma pulchrum Sowerby, *Proc. Zool. Soc. London*, June 5, 1832, p. 57. "Hab. in Sinu Caraccensi, Americae Meridionalis." —Sowerby, Conchyl. Illustr., Catal. issued with Pt. 19, species No. 2, pl. 17, fig. 2, issued between January 18 and March 8, 1833, "St. Elena W. Columbia." Var. fig. 2*. Panama.

Amphidesma pulchra Sowerby, Reeve, Conch. Icon., Vol. 8, *Amphidesma*, October, 1853, species 2, pl. 1, fig. 2. Original locality cited.

Type Locality: Bay of Caraccas, Ecuador.

Range: Gulf of Fonseca, Nicaragua, to Ecuador.

Collecting Stations: Nicaragua: Poto and 5 miles SSW. of Monypenny Point, Gu of Fonseca.

Description: Shell trigonally ovate, fair thick, anterior side the longer, sloping an rounded at the end; posterior side with fold, the end roundly truncated; ventr margin rounded; sculptured with fine clos concentric riblets, on the anterior end thes are decussated by several (10-15) incise radial lines; color pale yellowish-gray wit purple blotches and ∧-shaped marking pallial sinus higher in front of the adducto impression then gently sloping to a broadl rounded end which projects forward abou three-fifths the length of the shell; hing normal; interior colored white with the un bonal half and the hinge purple or tinge with purple.

A typical specimen from Nicaragua mea sures: length, 31 mm.; height, 25.4 mm. convexity (both valves together), 12.5 mm. pallial sinus projects anteriorly 19.8 mm from the posterior margin of the shell.

The shells here referred to *Semele pulchr* agree exactly with the figures of that specie given by Sowerby and by Reeve. *Semele quen tinensis* Dall, a closely related species whic has usually been cited under the name o *S. pulchra*, occurs from southern Californi to Central America. It is more elongate i outline, the anterior dorsal margin slope more gently from the beaks, the shell i thinner and the purple coloration is mor weakly developed.

Distribution: Only three specimens of thi species were taken by the expedition in th Gulf of Fonseca. It ranges south to Ecuador

***Semele quentinensis* Dall.**

Plate I, Fig. 10.

Semele quentinensis Dall, *West Amer. Sci* Vol. 19, No. 3, June 15, 1921, p. 22. "Pliocen or Early Pleistocene of San Quentin."—Dall *Proc. U. S. Nat. Mus.*, Vol. 66, No. 2554, Art 17, 1925, p. 26, pl. 8, fig. 4. "Pliocene (?) o San Quentin Bay, Lower California."

Type Locality: San Quintin, Lower Cali fornia, Pleistocene.

Range: Point Mugu, Ventura County, Cali fornia, to Costa Rica.

Collecting Stations: Guatemala: 7 mile west of Champerico (197-D-2), 14 fathoms mud; El Salvador: Meanguera Island, Gul of Fonseca (199-D-1), 16 fathoms, sand mud, crushed shell; Nicaragua: Corint (200-D-19), 12-13 fathoms, mangrov leaves; Costa Rica: 1 mile south of Golfito

Description: Shell small, inequilateral, in equivalve, rather compressed, anterior en longer, terminally rounded; posterior en obscurely subtruncate, base moderately ar cuate; beaks inconspicuous; surface finel concentrically closely sculptured, with fin radial threads chiefly visible in the sulci; a the anterior end are about a dozen stronge sulci, cutting and more or less beading th concentric sculpture, but this feature is no

repeated at the posterior end; hinge normal, well developed; pallial sinus large, subovate, nearly reaching the anterior adductor scar, and entirely free from the pallial line; the left valve slightly flatter than the right valve. Length, 24; height, 19; diameter, 8 mm. (Original description).

A large specimen from the Gulf of Fonseca in the present collection measures: length, 27.3 mm.; height, 20.8 mm.; convexity (both valves together), 8.9 mm.; pallial sinus extends anteriorly 18 mm. from the posterior margin of the shell.

The shell of this species is very similar to that of *Semele pulchra* but the length is greater in proportion to the height and the anterior dorsal margin slopes more gently from the beaks. The specimens in the present collection are thinner and the purple coloration is less pronounced than that of *S. pulchra*. These shells possess fine, even, concentric sculpture which along the anterior dorsal margin is crossed by incised radial lines giving a beaded appearance to that portion of the shell. These specimens agree exactly with Dall's description and illustration of *Semele quentinensis* which was based on a fossil specimen from the Pleistocene of San Quintin, Lower California. These appear to be identical with the species occurring in southern California which generally has been cited in the literature under the name of *Semele pulchra*. The only difference seems to be in size, those from southern California seldom exceeding 20 mm. in length. A few specimens of this northern form also possess a few incised radial lines along the posterior dorsal margin but they are fewer and much weaker than those on the anterior dorsal margins and thus differ from the sculpture of *Semele jaramija* Pilsbry & Olssen which was originally described from the Pliocene of Ecuador. *Semele guaymasensis* Pilsbry & Lowe has more widely spaced and coarser concentric sculpture.

Distribution: Specimens of *Semele quentinensis* were dredged by the expedition in 12 to 16 fathoms from Guatemala to Costa Rica. It also is known to occur in the Pleistocene of southern California and Lower California.

Semele simplicissima Pilsbry & Lowe.

Semele simplicissima Pilsbry & Lowe, *Proc. Acad. Nat. Sci. Philadelphia*, Vol. 84, May 21, 1932, p. 93, pl. 12, figs. 6, 6a. "Acapulco, 20 fathoms."

Type Locality: Acapulco, Mexico, in 20 fathoms.

Range: Santa Inez Bay, Gulf of California, to Acapulco, Mexico.

Collecting Stations: Mexico: Arena Bank (136-D-2, 5), 33-45 fathoms, mud, *Arca* congomerates, sand, weed; Santa Inez Bay (143-D-2, 3, 4), 25-35 fathoms, mud, crushed shell; Santa Cruz Bay (195-D-21), 18 fathoms, mud; Costa Rica: Port Parker (203-D-3), 12 fathoms, shelly mud; 14 miles S. × E. of Judas Point (214-D-1, 4), 42-61 fathoms, mud, shell, rocks.

Description: Shell ovate, thin, moderately inflated at the umbos, beaks near the middle; anterior dorsal margin sloping, nearly straight, end rounded, ventral margin broadly rounded, posterior end a little higher than the anterior, convex dorsally, in large specimens decidedly truncated at the end where the fold reaches the margin; sculpture of very fine, fairly regular, low, concentric ridges which are covered by such fine, concentric lines that they disperse light into spectral colors; the interspaces are flat and without either concentric or radial striation; lunule lanceolate and rather deeply concave; pallial sinus ascending, rounded at the end and projecting a little beyond the middle of the shell; color dingy white and on the interior of fresh specimens a salmon pink or dark orange flush covers the umbonal half of the shell.

Some specimens in the present collection are much larger than the type of this species. The largest shell, a left valve, measures: length, 33 mm.; height, 24.3 mm.; convexity (one valve), 6.4 mm.; pallial sinus projects anteriorly 19 mm. from the dorsal margin of the shell. One pair of valves from Arena Bank measures, approximately: length, 29.5 mm; height, 22.8 mm.; convexity (both valves together), 12.2 mm.; pallial sinus extends anteriorly 16.5 mm. from the posterior margin of the shell.

The present specimens have been identified after a comparison with paratypes of *Semele simplicissima* in the H. N. Lowe collection in the San Diego Society of Natural History. This species appears to be very similar to the one described as *Semele regularis* Dall[21] [=*Semele paziana*, new name], but differs in that the intervals between the ribs are smooth and usually not ornamented by concentric striations. However, some specimens here referred to *S. simplicissima* bear submicroscopic striae in the interspaces.

Semele sayi Toula, 1909, described from the Gatun Miocene of Panama, and especially *S. quirosana* H. K. Hodson, 1931, described from the Upper Oligocene or Miocene of Venezuela, bear a resemblance to *S. simplicissima*.

Distribution: Specimens of this species were dredged by the expedition from Santa Inez Bay in the Gulf of California, to off Judas Point, Costa Rica, at depths of 12 to 61 fathoms. These records of occurrence furnish new extensions both north and south of the known range of the species.

Semele sparsilineata Dall.

Plate I, Fig. 8.

Semele sparsilineata Dall, *Proc. Acad. Nat.*

[21] *Semele regularis* Dall, *Proc. Acad. Nat. Sci. Philadelphia*, Vol. 67, issued March 2, 1915, p. 27. "Gulf of California, off La Paz, in 10 to 30 fathoms."
Not *Semele regularis* E. A. Smith, Sci. Res. Voy. Challenger, Zool., Vol. 13, Lamell., 1885, p. 87, pl. 5, figs. 4, 4a, 4b. East of Cape York, North Australia in 155 fathoms.
A new name *Semele paziana* is here proposed for the west American species named *Semele regularis* by Dall.

Sci. Philadelphia, Vol. 67, issued March 2, 1915, p. 26. "Panama, 18 fathoms." Also recorded from "Chile, Hupé."

Type Locality: Panama, in 18 fathoms.

Range: Corinto, Nicaragua, to Taboga Island, Panama. To Chile (Dall).

Collecting Station: Panama: Gulf of Chiriqui (221-D-1, 5), 35-40 fathoms, sandy mud.

Description: Shell ovately oblong, the anterior portion much the longer, the end rounded, ventral margin rounded, posterior end slightly higher, slightly subtruncated, a flexure present; sculptured by fine concentric lines of growth which, sometimes anteriorly and sometimes medially, are crossed by fine oblique striations; pallial sinus ascending, broadly rounded at the end, projecting forward about three-fifths the length of the shell; color dingy white with traces of brownish-purple stains.

The larger specimen in the collection, a right valve, measures approximately: length, 25.5 mm.; height, 20.8 mm.; convexity (one valve), 4.7 mm.; pallial sinus extends anteriorly 15.8 mm. from the posterior margin of the shell.

The present specimens are somewhat worn but they show the oblique striae characteristic of this species. It was upon the basis of sparser oblique striae that Dall separated this species from the east American *Semele purpurascens* Gmelin[22].

Distribution: Only two single valves of this species were dredged by the expedition in the Gulf of Chiriqui, Panama, in 35-40 fathoms.

Semele tabogensis Pilsbry & Lowe.

Semele tabogensis Pilsbry & Lowe, *Proc. Acad. Nat. Sci. Philadelphia,* Vol. 84, May 21, 1932, p. 91, pl. 12, figs. 5, 5a, 5b. "Taboga Island, among rocks near the bathing beach."

Type Locality: Taboga Island, Panama, among rocks.

Range: Tangola-Tangola Bay, Mexico, to Taboga Island, Panama.

Collecting Station: Mexico: Tangola-Tangola Bay (196-D-7), 6 fathoms, sand.

Description: The shell is thin, orange, shading through pink into light coral red near the umbones; very shortly oval, strongly compressed, slightly inequilateral. The broadly rounded anterior end is somewhat lower than the posterior end, which is noticeably truncate. Dorsal margin somewhat concave in front of the beaks, convex behind them. In the right valve these margins are produced towards the other valve, covering the ligament. Ventral margin is strongly convex. Sculpture of regular, recurved concentric riblets, which become laminar near the dorsal margin, and are somewhat darker colored than their intervals, in which fine, weak, radial striation is seen. Beaks smooth. Lunule extremely small, confined to the right valve. The interior varies in color from carnelian red to apricot orange, smooth, with some scattered glossy dots. Teeth are lighter or whitish in large individuals. Anterior lateral short, the posterior long and thinner. The pallial sinus reaches well past the middle. Length 37.5 mm., height 30.3 mm., semidiam. (right valve) 6.5 mm. (Original description).

The present specimen, a left valve, measures approximately: length, 22.3 mm.; height, 17.3 mm.; convexity (one valve), 4.3 mm.

Distribution: A single left valve of this species was dredged by the expedition in Tangola-Tangola Bay, Mexico, in 6 fathoms. This is an extension north of the known range of this species.

Semele venusta Reeve.

Plate I, Fig. 13.

Amphidesma venusta Reeve, Conch. Icon., Vol. 8, *Amphidesma,* October, 1853, species 3, pl. 1, fig. 3. "Hab. West Columbia."—A. Adams, *Proc. Zool. Soc. London* for 1853 (issued July 25, 1854), p. 96. "Hab. West Columbia. Mus. Cuming."

Type Locality: West Colombia.

Range: Acapulco, Mexico, to west Colombia.

Collecting Stations: Mexico: Port Guatulco (195-D-9), 7 fathoms, gr. sand, crushed shell; Santa Cruz Bay; Tangola-Tangola Bay (196-D-8), 9 fathoms, sand.

Description: Shell oblong, transverse, ventricose, rather shining, dull flesh-color, obscurely rayed with rose, anterior side much the longer, posterior slightly truncated, flexuous at the ventral margin; concentrically grooved; purple within, edged with white (Reeve).

A left valve in the present collection from Santa Cruz Bay, Mexico, measures: length, 21.9 mm.; height, 15 mm.; convexity (one valve), 4.2 mm.; pallial sinus extends anteriorly 14 mm. from the posterior margin of the shell.

The pallial sinus of this shell is a distinctive feature. It extends forward about two-thirds the length of the shell; it is broad and higher in front of the posterior adductor impression then tapers elliptically to a rounded point.

The ribbing of *Semele venusta* is somewhat irregular toward the anterior and posterior ends similar to that of *S. incongrua* Carpenter[23] athough coarser ventrally. The

---

22 *Venus purpurascens* Gmelin, Syst. Nat., ed. 13, Vol. 1, Pars. 6, 1791, p. 3288. Habitat unknown. Ref. to: "List. Conch. t. 303. f. 144."; "B (List. Conch. t. 304. f. 145."; "Klein. ostr. t. 11. f. 57".)

Tellina obliqua Wood, Gen. Conch., 1815, p. 152, pl. 41, figs. 4, 5.

This is not *Amphidesma purpurascens* Sowerby (Conch. Illustr., Pt. 19, species No. 19, pl. 18, fig. 5, issued between January 18 and March 8, 1833. "St. Elena. W. Col. Mr. Cuming."—Sowerby, *Proc. Zool. Soc. London* for 1832 (issued March 13, 1833), p. 199. "Hab. ad Sanctam Elenam." "A single valve of this elegant species was picked up on the sands at St. Elena".—Reeve, Conch. Icon., Vol. 8, *Amphidesma,* November, 1853, species 37, pl. 6, fig. 37), which was renamed *Semele sowerbyi* by Lamy (*Bull. Mus. Nat. Hist. Nat.* (Paris), Vol. 18, No. 3, 1912, p. 165, footnote).

23 *Semele incongrua* Carpenter, Rept. Brit. Assoc. Adv. Sci. for 1863 (issued August, 1864), pp. 611, 640. "Catalina

shell in adult forms is thicker than that of Carpenter's species. Fine radial sculpture is present in the bottoms of the interspaces.

A few small specimens in the present collection from off western Mexico are remarkably similar to *Semele incongrua*. Traces of the pallial sinus appear to be narrowly elliptical at the end similar to that of *S. venusta* rather than broady rounded as in *S. incongrua*.

The form described as *Semele pulchra* var. *montereyi* Arnold[24], based on a Pleistocene fossil from San Pedro, California, is, as mentioned by Dall, a subspecies of *S. incongrua*. The type specimen has not been illustrated but the figure given by Arnold represents a shell which appears to be a little more rounded, with sharper, more erect concentric lamellae and with stronger radial ornamentation than that of *S. incongrua*.

Verrill[25] considered *semele venusta* to be but a young form of *S. formosa* Sowerby. The pallial sinus, elliptically pointed in *S. venusta*, is quite different from the broadly rounded ascending pallial sinus of *S. formosa*.

Distribution: A few valves of *Semele venusta* were taken by the expedition at Port Guatulco, Santa Cruz Bay, and Tangola-Tangola Bay, Mexico, in 7 to 9 fathoms.

Semele verrucosa Mörch.

Plate I, Figs. 21, 24.

Semele (*Amphidesma*) *verrucosa* Mörch, Malakozool. Blätter, Bd. 7, December, 1860, p. 190. "Los Bocorones ad prof. 20 org. spec. 2". Costa Rica.

Type Locality: Los Bocorones Islands, Costa Rica.

Range: Los Bocorones Islands, Costa Rica, to Hannibal Bank, Panama.

Collecting Station: Panama: Hannibal Bank (Sta. 224), 35-40 fathoms, rocks, coral, mud, sand, shells, algae.

Description: Shell elongately ovate, inequilateral, whitish blotched with purple; anterior side the longer, the end rounded, ventral margin broadly rounded, posterior end broadly rounded and with a gentle fold; sculpture consists of close concentric ribs, these especially anteriorly and posteriorly are wrinkled and give rise to scalloped scale-like projections, the whole finely radially wrinkled; hinge (right valve) with two cardinals and laterals; pallial sinus broadly rounded at the end and gently ascending to about five-eighths the length of the shell.

A right valve measures approximately: length, 43 mm.; height, 32.4 mm.; convexity (one valve), 7.1 mm.; pallial sinus extends anteriorly 26.6 mm. from the posterior margin of the shell.

Mörch pointed out that the shell of *Semele verrucosa* is more elongate in outline, more subtruncate posteriorly, and that the ventral margin is more gently arcuate in outline than that of *S. formosa* Sowerby[26]. The present specimen possesses those characters as well as the pronounced scaly verrucose sculpture characteristic of Mörch's species.

Distribution: A single right valve of this species was dredged by the expedition on Hannibal Bank, Panama, in 35-40 fathoms. This is an extension south of the known range of the species.

Genus *Abra* Lamarck.

Abra Lamarck, Hist. Nat. Anim. s. Vert., Vol. 5, July, 1818, p. 492. Species cited: *"Amphidesma tenuis"* in the synonymy of which was included, *"Mactra tenuis.* Maton, act. soc. linn. 8. p. 72. no. 8" and *"Abra tenuis.* Leach". "Habite les mers d'Angleterre. Communiqué par M. Leach"; *"Amphidesma prismatica"* in the synonymy of which was cited, *"Ligula prismatica.* Montagu. test. brit. suppl. 23. t. 26. f. 3. Ex D. Leach." and *"Abra prismatica.* Leach." "Habite les côtes d'Angleterre. Communiqué par M. Leach."—Gray, *Proc. Zool. Soc. London* for 1847, p. 187. Type: *Mactra tenuis.*—Dall, *Trans. Wagner Free Inst. Sci.*, Vol. 3, Pt. 5, 1900, p. 995. Type: *A tenuis* Montagu.—Woodring, *Carnegie Inst. Washington, Pub.* 366, 1925, p. 179. Type: *Mactra tenuis* Montagu.

Type (designated by Gray, 1847) : *Mactra tenuis* [Montagu, Test. Brit., Pt. 2, 1803, p. 572, Suppl., 1808, pl. 17, fig. 7. "Southampton, where it is not uncommon on the shore to the west of the town." Also from "Weymouth"—Forbes & Hanley, Hist. Brit. Moll., Vol. 1, 1853 (issued 1848), p. 323, pl. 17, fig. 7. Various localities in England]. [For dates of publication of this work see Fisher and Tomlin, *Jour. Conch.*, Vol. 20, No. 5, August, 1935, pp. 150-151].

Shell small, trigonal; sculpture consisting of incrementals; ligament narrow, resilium seated on a wide, deeply inset chondrophore; hinge of right valve consisting of 2 cardinals (3a, 3b), the posterior one (3b) heavier, and slender anterior and posterior laterals; hinge of left valve consisting of 2 cardinals (2a, 2b), the posterior one (2b) very small; pallial sinus deep, very wide, confluent with pallial line (Woodring).

The genus *Abra* has been recorded as occuring from Eocene to Recent.

Is., 40-60 fm.; common." Reprint in *Smithson. Miscell. Coll.*, No. 252, 1872, pp. 97, 126.—Carpenter, *Proc. California Acad. Nat. Sci.*, Vol. 3, February, 1865, p. 208 (as *Semele incungrua*). "Hab. Santa Barbara, 16 fm. 1 valve; Catalina Island, 40-60 fm., not uncommon; Cooper."—I. S. Oldroyd, *Stanford Univ. Publ. Univ. Ser. Geol. Sci.*, Vol. 1, 1924, p. 181, pl. 11, figs. 12, 13. "Type locality, Santa Barbara." Range, Monterey, California, to the Coronado Islands, Lower California.

[24] *Semele pulchra* Sowerby, var. *montereyi* Arnold, *Mem. Calif. Acad. Sci.*, Vol. 3, 1903, p. 166, pl. 15, figs. 3, 3a. Lower San Pedro series, San Pedro, California. Pleistocene. Recent in Monterey Bay.

[25] Verrill, A. E., *Amer. Jour. Sci.*, Ser. 2, Vol. 69, No. 146, March, 1870, p. 219.

[26] *Amphidesma formosum* Sowerby, Conch. Illustr., Catal. issued with Pt. 19, No. 4, pl. 19, fig. 8 [two figs.], issued between January 18 and March 8, 1833. "St. Elena. Mr. Cuming."—Sowerby, *Proc. Zool. Soc. London* for 1832 (issued March 13, 1833), p. 199. "Hab. ad Sanctam Elenam." "Only two odd valves were dredged in seven fathoms water."—Reeve, Conch. Icon., Vol. 8, *Amphidesma*, 1853, species 27, pl. 4, fig. 27 (as *Amphidesma formosa*). Original locality cited.

Lamy[27] cited *Mactra tenuis* Montagu, the type of *Abra*, and similar species, under the genus *Syndesmya* Recluz, 1843, with the type *Mactra alba* Wood, 1801.

Iacra H. & A. Adams, 1856, a subgenus of *Abra*, with the type *Scrobicularia seychellarum* A. Adams, 1856, possesses divaricate radial sculpture.

Abranda Iredale, 1924, is based upon *Abranda rex* Iredale, an Australian species.

KEY TO THE SPECIES OF *Abra*.

A. Shell elongate
   a. Posterior end pointed ..... *pacifica*[28]
   aa. Posterior end blunt ..... *tepocana*[28]
B. Shell short; high, inflated ..... *palmeri*

Abra palmeri Dall.

Plate I, Figs. 16, 18, 20, 23.

Abra palmeri Dall, *Proc. Acad. Nat. Sci. Philadelphia*, Vol. 67, March 2, 1915, p. 28. "Ballenas Lagoon on the west coast of Lower California; the Gulf of California (Dr. E. Palmer); and Panama Bay in 26 fathoms (U. S.N.Mus.). Type locality, Panama Bay. (U. S.N.Mus., No. 96,301.)"

Type Locality: Panama Bay, in 26 fathoms.

Range: Ballenas Lagoon on the west coast of Lower California, and the Gulf of California to Panama Bay.

Collecting Station: El Salvador: Meanguera Island, Gulf of Fonseca (199-D-1), 16 fathoms, sand, mud, crushed shell.

Description: Shell short, high, inflated, white, with a silky surface, and a very thin, polished, pale yellow periostracum; anterior end and base rounded; beaks subcentral, dorsal margins descending, posterior end attenuated and with the extremity rounded; right valve with a deeply bifid (or double) cardinal tooth, the laterals obsolete; left valve with a single cardinal and no laterals. Length 10, height 8, diameter 5.5. mm. The pallial sinus rounded, 6 mm. deep. (Original description).

This species is nearest to *A. lioica* Dall, of the Atlantic Coast of the United States (Dall).

The largest specimen in the present collection measures: length, 10.5 mm.; height, 9.2 mm.; convexity (one valve), 2.8 mm.

The short and high outline of *Abra palmeri* separates it from the two other species described from west American waters, *A. pacifica* Dall, 1915, and *A. tepocana* Dall, 1915, both of which were said to be elongate in outline.

Distribution: Several specimens of this species, mostly single valves, were dredged off Meanguera Island, El Salvador, in the Gulf of Fonseca, in 16 fathoms. This is the first record of the occurrence of the species since its original description.

[27] Lamy, E., *Journ. de Conchyl.*, Vol. 61, No. 3, 1914, pp. 268-297.

[28] Not represented in the present collection.

Genus *Cumingia* Sowerby.

Cumingia lamellosa Sowerby.

Cumingia lamellosa Sowerby, *Proc. Zoo Soc. London*, May 17, 1833, p. 34. "Hab. prop littora Oceani Pacifici." "Found at Payta i hard clay at low water; and at Panama i deep water."—Sowerby, Gen. Rec. and Foss Shells, *Cumingia*, Vol. 2, No. 40, ?1833, p 244, fig. 3.—Sowerby, Conch. Icon., Vol. 19 *Cumingia*, 1873, species 5, pl. 1, fig. 5. "Hab Chili".— Lamy, *Journ. de Conchyl.*, Vol. 61 No. 3, 1914, p. 310. Paita, Peru.

Cumingia coarctata Sowerby, *Proc. Zoo Soc. London*, May 17, 1833, p. 34. "Hab. a Sinum Caraccensem." "Dredged from sandy muddy bottom in seven fathom water in the Bay of Caraccas". [Ecuador].

Cumingia trigonularis Sowerby, *Proc Zool. Soc. London*, May 17, 1833, p. 35. "Hab ad Sanctam Elenam." "Found among stone in deep water."—Sowerby, Gen. Rec. an Foss. Shells, Vol. 2, No. 40, ?1833, *Cumingia* pl. 244, fig. 2.—Sowerby, Conch. Icon., Vol 19, *Cumingia*, 1873, species 4, pl. 1, fig. 4 "Hab. Chili?"

Cumingia adamsii Carpenter, *Proc. Zool Soc. London*, June 23, 1863, p. 367. Reprint i *Smithson. Miscell. Coll., No.* 252, 1872, p. 203 Name proposed for *Cumingia*, sp. indet. *c* o C. B. Adams, *Ann. Lyceum Nat. Hist. New York*, Vol. 5, July, 1852, p. 512 (separate p 288). "Near Panama."

Cumingia moulinsii De Folin, Les Méléa grinicoles (Havre), 1867, p. 16, pl. 2, figs. 12 13, 14, 15. . . . "l'Océan pacifique" . . . "pê chêes aux environs des Negritos" . . . or . . "autour des îles aux Perles, dans la baie d Panama".—De Folin & Périer, Les Fonds d la Mer, Vol. 1, 1867, p. 8. Bay of Panama [For dates of publication of this work see H A. Rehder, *Proc. Malacol. Soc. London*, Vol 27, Pt. 2, September 5, 1946, pp. 74-75].

Type Locality: Paita, Peru, at low water in hard clay (here designated as type locality). Panama, in deep water, also cited originally.

Range: San Martin Island, Lower California, to the Gulf of California and south t Paita, Peru.

Collecting Stations: Mexico: Port Guatul co (195-D-9), 7 fathoms, gr. sand, crushed shell; Nicaragua: Corinto (200-D-10, 16, 17 19), 4-13 fathoms, mangrove leaves, sand also on shore; Costa Rica: Port Parker.

Description: Shell oblong, regularly con centrically laminated, laminae narrow, standing out, distant; anterior side short, rounded posterior side angular, acuminated, subro strated; ventral margin contracted near th end; dorsal margin sloped (Sowerby, Conch Icon., Vol. 19).

Some of the larger specimens in the pres ent collection are about 12 mm. in length Some specimens attain a length of 20 mm. o more.

Cumingia lamellosa lives in sand, sponge and in fissures in rocks. Consequently i

shows great variation in the shape of the shell and in the development of the lamellae. This variation has led to the publication of a number of different names for this species by various authors.

The more northern *Cumingia californica* Conrad, has a larger and thicker shell. *Cumingia similis* A. Adams is a synonym of Conrad's species.

Cumingia mutica Sowerby[29], which occurs in Peru and Chile, possesses a large shell for the genus. It is ornamented by finely decussated scupture. *Cumingia clerii* A. Adams[30], *C. grandis* Deshayes[31], *C. striata* A. Adams[32] and *C. ventricosa* Sowerby[33] were referred to the synonymy of *C. mutica* by Dall.

Cumingia lamellosa Sowerby is not to be confused with *Thyella lamellosa* H. Adams, 1885, described from the island of Mauritius, later renamed *Cumingia elegans* by Sowerby, 1873.

Cumingia tellinoides Conrad, 1831, *C. tellinoides coarctata* Sowerby, 1833, and *C. tellinoides vanhyningi* Rehder, 1939, occur in east American waters.

Distribution: Specimens of *Cumingia lamellosa* were taken by the expedition off western Mexico, Nicaragua and Costa Rica. Specimens questionably identified as this species have been recorded as occurring in the Pleistocene of Magdalena Bay, Lower California.

Family Donacidae.

Key to the Genera of the Donacidae.

A. Inner margin crenulated ..... *Donax*
B. Inner margin smooth ..... *Iphigenia*

Genus **Donax** Linnaeus.

Key to the Species of *Donax*.

A. Shell more than twice as long as high
  a. Anterior dorsal margin concave *transversus*
  aa. Anterior dorsal margin straight or convex
    b. Posterior dorsal area flattened or rounded
      c. Shell flattened; very elongate *gracilis*
      cc. Shell moderately inflated; higher ..... *californicus*
    bb. Posterior dorsal area concave; posterior area smoky-black; shell subrhomboidal ..... *navicula*
B. Shell less than twice as long as high
  a. Shell with a sharply angled umbonal carina posteriorly
    b. Thin; anterior end acutely rounded; highly polished ..... *carinatus*
    bb. Thick; anterior end more broadly rounded ..... *rostratus*[34]
  aa. Shell with a rounded umbonal angulation posteriorly; strongly sculptured
    c. Interspaces punctate (with a row of fine pits)
      d. Shell subtriangular (typical), high; posterior margin sloping rather steeply; ventral margin sometimes slightly expanded medially *punctatostriatus*
      dd. Shell elongate, lower; flatter; posterior margin sloping more gently, posterior end rostrate; base more broadly rounded
        e. Moderately elongated *contusus*[34]
        ee. Extremely elongated; posterior dorsal margin somewhat rounded *culter*[34]
    cc. Interspaces not punctate
      f. Length not exceeding 15 mm.; sculpture finely cancellate *obesus*
      ff. Length exceeding 15 mm.; sculpture coarsely cancellate; thick
        g. Beaks subcentral; shell high, trigonal
          h. Ribs on posterior area of about equal size ..... *asper*
          hh. Ribs on posterior area with 1-3 coarser than the others *dentiferus*[34]
        gg. Beaks decidedly posterior; shell more elongated *assimilis*

Donax asper Hanley.

Donax asper Hanley, *Proc. Zool. Soc. London*, Pt. 13, April, 1845, p. 14. "Hab. Tumbez, Peru (Cuming)."—Reeve, Conch. Icon., Vol. 8, *Donax*, September, 1854, species 12, pl. 2,

29 *Cumingia mutica* Sowerby, *Proc. Zool. Soc. London*, May 17, 1833, p. 34. "Hab. prope littora Maris Pacifici." Obtained "at Conception in seven fathoms, sand and mud; at Iquiqui in nine fathoms, gravel and mud; at Payta in hard clay at low water; and at Muerte."—Sowerby, Conch. Icon., Vol. 19, *Cumingia*, 1873, species 3, pl. 1, fig. 3. "Hab. Chili, Peru."

30 *Cumingia clerii* A. Adams, *Proc. Zool. Soc. London*, November 12, 1850, p. 24, pl. 8, fig. 3. "Found at Talcuhano, Chili, by Capt. Clery, French Marine, attached to fuci in shallow water. (Mus. Cum.)."—Sowerby, Conch. Icon., Vol. 19, *Cumingia*, 1873, species 2, pl. 1, fig. 2. "Hab. Chili."

31 *Cumingia grandis* Deshayes, *Journ. de Conchyl.*, Vol. 5, 1857, p. 281, pl. 8, figs. 4 and 5. . . . "provient des mers du Chili".—Sowerby, Conch. Icon., Vol. 19, *Cumingia*, 1873, species 11, pl. 2, fig. 11. "Hab. Chili".

32 *Cumingia striata* A. Adams, *Proc. Zool. Soc. London*, November 12, 1850, p. 25, pl. 8, fig. 5. "Hab. Conception; seven fathoms, sandy mud; H. C. (Mus. Cuming)."

33 *Cumingia ventricosa* Sowerby, Conch. Icon., Vol. 19, August, 1873, species 10, pl. 2, fig. 10. "Hab. Probably Chili."

34 Not represented in the present collection.

fig. 12. Original locality record cited.—Sowerby, Thes. Conch., Vol. 3, 1866, p. 307, pl. 280 (*Donax*, pl. 1), fig. 24. Tumbez, Peru.

Donax (Hecuba) asper Hanley, Römer, Syst. Conchyl.-Cab. Martini-Chemnitz, Bd. 10, Abt. 3, *Donacidae*, 1869, p. 14, Tab. 3, figs. 7-10. Tumbez, Peru; Puntarenas, Costa Rica, in the Gulf of Nicoya.

Donax aspera Hanley, Dall, *Proc. U. S. Nat. Mus.*, Vol. 37, 1909, pp. 159, 273, pl. 28, fig. 7. Central America to Tumbez, Peru.

Type Locality: Tumbez, Peru.

Range: Tangola-Tangola Bay, Mexico, to Tumbez, Peru.

Collecting Stations: Mexico: Tangola-Tangola Bay; Costa Rica: Port Culebra, beach; Culebra Bay; Cedro Island, Gulf of Nicoya, beach; Gulf of Dulce, beach; Panama: Bahia Honda.

Description: Shell triangular, beaks subcentral, elevated, and rather gibbous; the anterior end is rather acutely rounded, the posterior end somewhat concavely truncated; ornamented by radiating riblets which are especially well developed toward the posterior end and on the posterior area where they are crenated by concentric lines; inner margin crenulated; the color is ashy-white or purple.

A large right valve in the present collection from the Gulf of Dulce measures, approximately: length, 35 mm.; height, 26 mm.; convexity (one valve), 8.5 mm.

Compared to *Donax assimilis* Hanley, the shell of *D. asper* is much higher in proportion to the length and the beaks are much more centrally located. The shell of *D. asper* differs from that of *D. dentiferus* Hanley[35] in that it is thicker, more acutely rounded anteriorly and lacks the raised ribs (1-3) which are coarser than the others on the posterior area of that species.

Distribution: This species was collected by the expedition from Mexico to Panama but nowhere in large numbers. Several single valves were taken on the beach in the Gulf of Dulce, Costa Rica, and at Tangola-Tangola Bay, Mexico.

Donax assimilis Hanley.

Donax assimilis Hanley, *Proc. Zool. Soc. London*, Pt. 13, April, 1845, p. 17. "Hab. Panama. Mus. Cuming, Hanley, &c."—Reeve, Conch. Icon., Vol. 8, *Donax*, September, 1854, species 10, pl. 2, fig. 10. Panama.

Donax panamensis Philippi, *Zeit. f. Malakozool.*, Jahrg. 5, No. 10, 1848, p. 145. "Patria: Panama." [According to Römer, 1869, this species is a synonym of *D. assimilis*.]

Donax cayennensis Lamarck, Reeve, Conch. Icon., Vol. 8, *Donax*, September, 1854, species 22, pl. 4, figs. 22a, 22b. "Hab. Panama and St. Elena, West Columbia; Cuming."

Not *Donax caianensis* Lamarck, Anim. S. Vert., Vol. 5, July, 1818, p. 550. "Habite l'Océan de la Guyane."—Delessert, Rec. Coq décrites par Lamarck et non encore figurées 1841, pl. 6, figs. 13a, 13b. See also Hanley Cat. Rec. Biv. Shells, 1843, p. 82, footnote.— Lamy, *Bull. Mus. Nat. Hist. Nat.* (Paris) Vol. 20, No. 6, 1914, p. 339.

Donax reevei Bertin, *Nouv. Arch. Mus Hist. Nat.* (Paris), Ser. 2, Vol. 4, 1881, p. 85 [Name based upon Reeve's pl. 2, fig. 10 Panama (Reeve).]

Donax sowerbyi Bertin, *Nouv. Arch. Mus Hist. Nat.* (Paris), Ser. 2, Vol. 4, 1881, p. 85 pl. 4, figs. 2a, 2b, 2c. Based upon Sowerby' (Thes. Conch., Vol. 3, 1866, p. 307), pl. 28 (*Donax*, pl. 1), fig. 21. "Panama."

Type Locality: Panama.

Range: Mazatlan, Mexico (Carpenter), t Santa Elena, Ecuador.

Collecting Stations: Nicaragua: Isla En cantada, Corinto; Costa Rica: Culebra Bay Cedro Island, Gulf of Nicoya, beach; Gulf o Dulce, beach; Panama: Isla Parida, Gulf o Chiriqui.

Description: Shell elongately triangular beaks posterior to the middle, anterior end the narrower, rounded, posterior end trun cated; ornamented with radial riblets which are stronger toward the posterior end and on the posterior area which sometimes bears a faint subangulation; inner margin crenated color, usually some shade or combination of gray and purple.

A large specimen of this species in the collection of the California Academy of Sciences, collected by James Zetek at Chame Island, Panama, measures: length, 41 mm.; height, 26.8 mm.; convexity (both valves together), 17.5 mm.

Compared to *Donax asper* the shell of *D. assimilis* is much more elongate, the beaks are more posteriorly situated and the posterior area is more rounded. The more posteriorly situated beaks and more elongated shell are characters which serve to separate the present species from *D. dentiferus*.

Distribution: This species was taken by the expedition on the beach at a few localities from Nicaragua to Panama. It occurs commonly at Panama where it is used for food by the natives.

Donax californicus Conrad.

Plate I, Figs. 2, 5.

D[*onax*]. *californica* Conrad, *Jour. Acad. Nat. Sci. Philadelphia*, Vol. 7, 1837, p. 254, pl 19, fig. 21. "Inhabits the coast of California in sand, near Sta. Barbara."

Not *Donax californica* Conrad, Reeve, Conch. Icon., Vol. 8, *Donax*, September, 1854 species 40, pl. 6, fig. 40. "Hab. Gulf of California." [Carpenter, 1855, referring to some of the shells in the Gulf of California region labeled as *D. californicus*, stated, "The shells wrongly called *D. californicus* are simply the white variety of the forms *contusus* and *culter*"].

Donax californicus Conrad, Arnold, *Mem. Calif. Acad. Sci.*, Vol. 3, 1903, p. 170, pl. 13

---

[35] *Donax dentifera* Hanley, *Proc. Zool. Soc. London*, Pt. 11, July, 1843, p. 6. "Hab.—?"—Reeve, Conch. Icon., Vol. 8, *Donax*, September, 1854, species 2, pl. 1, figs. 2a, 2b. "Hab. Panama."

fig. 9. Lower San Pedro Series at Deadman Island, and San Pedro, California. Lower Pleistocene. Also upper Pleistocene and Recent.—Weymouth, State of Calif. Fish & Game Comm., *Fish Bull.* No. 4, 1920, p. 47, pl. 16, fig. 1. Localities cited from San Pedro to False Bay, California.

Type Locality: Near Santa Barbara, California, in sand.

Range: Santa Barbara, California, to Magdalena Bay, Lower California.

Collecting Station: Mexico: Cedros Island, Lower California.

Description: Shell elongated, somewhat pointed at both extremities; disks with very minute radiating lines; color yellowish, obscurely rayed; a brown stripe on the anterior and posterior sub-margin; within white and purplish brown; margin beautifully crenulated. (Original description.)

A specimen of this species in the collections of the California Academy of Sciences, collected by Henry Hemphill at Cape San Lazaro, Lower California, measures: length, 24.6 mm.; height, 11 mm.; convexity (both valves together), 7.4 mm.; from beaks to posterior end, 10 mm. Large specimens attain a length of about 30 mm.

Donax californicus can be referred to the subgenus *Serrula* Chemnitz in Mörch.

The posterior dorsal area of the shell of this species is flattened or gently rounded rather than concave as in *D. navicula.*

Donax gracilis Hanley is a similar southern species whose shell is more elongated and whose posterior dorsal margin slopes more gently ventrally.

Distribution: A few small specimens of *Donax californicus* were dredged off Cedros Island by the expedition. We have not seen specimens from south of Cape San Lazaro, Lower California[36]. It is also known to occur in the Pleistocene of southern California and western Lower California.

Donax carinatus Hanley.

Plate I, Fig. 9.

Donax carinata Hanley, *Proc. Zool. Soc. London,* Pt. 11, July, 1843, p. 5. "Hab. —? Mus Stainforth, Metcalfe." — Hanley, Cat. Rec. Bivalve Shells, p. 84, 1843, p. 349, pl. 14, fig. 28, 1856 (as *Donax carinatus* on expl. to plate). [No locality cited.]—Reeve, Conch. Icon., Vol. 8, *Donax,* September, 1854, species 11, pl. 2, fig. 11. "Hab. San Blas, California."

Donax carinatus Hanley, Sowerby, Thes. Conch., Vol. 3, 1866, p. 305, pl. 280 (*Donax,* pl. 1), figs. 4 and 5. "California."—Römer, Syst. Conchyl.-Cab. Martini-Chemnitz, Bd. 10, Abt. 3, *Donacidae,* 1869, p. 10, Taf. 3, figs. 4, 5, 6. "Fundort: Der Stille Ocean bei Californien, (St. Blas, Tumaco, Mazatlan)."

Donax culminatus Carpenter, Cat. Mazatlan Shells, September, 1855, p. 43. "Hab. — 1 young specimen; L'pool Col."

Type Locality: San Blas, Mexico (here designated as type locality). No locality cited originally.

Range: Altata, Mexico, to Tumaco, Colombia.

Collecting Station: Nicaragua: Corinto (200-D-16, 19), 4-13 fathoms, mangrove leaves.

Description: Transversely elongated, convex, very inequilateral, purplish-brown, with more or less distinct radiating striae, (usually with obsolete darker rays and polished), ventral edge little arcuated and forming a very acute point with the nearly straight edge of the obliquely truncated and almost flattened anterior [posterior] slope, which is sharply carinated and sculptured by close decussated radiating striae: inside purple, two lateral teeth in each valve, the ventral edge crenated, anterior crenulated. 4/5 . . . 1 2/5 [inches] (Hanley, Cat. Rec. Biv. Shells, 1843).

The largest specimen in the present collection measures 33.2 mm. in length and 18 mm. in height. A large right valve collected by the senior author at Corinto, Nicaragua, measures approximately: length, 39.4 mm.; height, 22 mm.; convexity (one valve), 7.6 mm.

This species can be easily recognized by the comparatively thin, polished shell with a sharply angled umbonal ridge posteriorly.

The only other west American shell that might be confused with *Donax carinatus* is *Donax rostratus* C. B. Adams[37]. The shell of Adams' species is thicker, less sharply carinated, and is less sharply pointed where the carina joins the ventral margin, the anterior end is more broadly rounded, and the color of the exterior is lighter.

A subspecies, *Donax carinatus galvestonensis* Harris[38], has been described from an artesian well in Galveston, Texas, and was considered to be of upper Miocene age. Harris did not consider Reeve's plate 2, figure 11, as representing Hanley's species.

Distribution: This species was dredged by the expedition off Corinto, Nicaragua, at depths of 4-13 fathoms. It also has been collected by the senior author at Corinto and at Mazatlan, Mexico. Römer cited the occurrence of the species as far south as Tumaco, Colombia.

Donax gracilis Hanley.

Plate I, Figs. 4, 6.

Donax gracilis Hanley, *Proc. Zool. Soc. London,* Pt. 13, April, 1845, p. 15. "Hab. Bay of Guayaquil. Var. *b.* Chiriqui. Var. *c.* Bay of Caraccas (Cuming)." — Reeve, Conch.

[36] According to Miss Viola Bristol, specimens of this species from Magdalena Bay, Lower California, are in the collections of the San Diego Society of Natural History (*Min. Conch. Club South. Calif.,* No. 47, back page, April, 1945). On the same page of this paper Eyerdam is cited as having found this species at Corinto, Nicaragua.

[37] *Donax rostratus* C. B. Adams, *Ann. Lyceum Nat. Hist. New York,* Vol. 5, July, 1852, pp. 502, 545 (separate pp. 278, 321). "Panama."—Römer, Syst. Conchyl.-Cab. Martini-Chemnitz, Bd. 10, Abt. 3, *Donacidae,* 1869, p. 11, Taf. 3, figs. 1-3.

[38] *Donax carinata* var. *galvestonensis* Harris, *Bull. Amer. Paleo.,* Vol. 1, No. 3, December 2, 1895, p. 92 (10). Well at Galveston, Texas, depth, 2,552 to 2,920 feet. Upper Miocene.

Icon., Vol. 8, *Donax*, September, 1854, species 38, pl. 6, fig. 38. "Hab. Gulf of Guayaquil; Cuming."—Sowerby, Thes. Conch., Vol. 3, 1866, p. 314, pl. 282 (*Donax*, pl. 3), figs. 76, 77, 78, 79. Gulf of Guayaquil.—Römer, Syst. Conchyl.-Cab. Martini-Chemnitz, Bd. 10, Abt. 3, *Donacidae*, 1869, p. 80, Taf. 14, figs. 4, 5, 6. [?7, 8]. "Fundort: Der Stille Ocean bei Mittelamerika und Ecuador, (Guayaquil, Chiriqui, Panama)."

Type Locality: Bay of Guayaquil, Ecuador (here selected as type locality). Chiriqui [Panama] and Bay of Caraccas [Ecuador] also cited originally for varieties of this species.

Range: Lat. 24° 18′ N., west coast of Lower California, to the Gulf of California and south to Negritos, Peru.

Collecting Station: Nicaragua: Corinto (200-D-10, 11, 16, 17, 19), 7-13 fathoms, sand, mangrove leaves, also in beach drift.

Description: Shell narrowly elongate, polished, rather compressed, beaks nearer the posterior end; anterior end acutely rounded, posterior end acutely roundly pointed; posterior dorsal margin straight or slightly produced; inner margin finely crenulated; color of the exterior is usually brown and that of the interior brownish-purple.

A large left valve from off Potosi and Monypenny Point, Nicaragua, measures approximately: length, 22.5 mm.; height, 9.4 mm.; convexity (one valve), 3 mm.; distance from beak to posterior end, 9 mm.

The shell of *Donax gracilis* differs from that of *D. navicula* in the much more elongate outline and in that the posterior dorsal margin is straight or slightly produced rather than concave. Compared to *D. californicus* the shell of *D. gracilis* is longer in proportion to the height, more compressed, the posterior dorsal margin slopes more gently and the posterior end is more acutely pointed. It can be referred to the subgenus *Serrula*.

Donax punaensis Pilsbry & Olsson[39], described from the Pliocene of Ecuador, is a very similar species but the beaks appear to be more centrally situated and the posterior end is more broadly rounded.

Donax petersoni Olsson, described from the Oligocene of Peru, is a somewhat similar species.

Donax owenii Gray in Hanley[40] of the Atlantic fauna appears to be somewhat similar to *D. gracilis* but the posterior end appears to be shorter and the margin is said to b smooth not crenulated.

Distribution: Specimens of *Donax gracili* were taken by the expedition in the beach drift as well as dredged in 7 to 13 fathom at Corinto, Nicaragua.

Donax navicula Hanley.

Plate I, Fig. 1.

Donax navicula Hanley, *Proc. Zool. Soc London*, Pt. 13, April, 1845, p. 15. "Hab. Gul of Nicoya, Central America (Cuming)".— Reeve, Conch. Icon., Vol. 8, *Donax*, Septem ber, 1854, species 18, pl. 4, fig. 18. Origina locality cited.—Sowerby, Thes. Conch., Vo 3, 1866, p. 314, pl. 282 (*Donax*, pl. 3), fig 80. Original locality cited.—Römer, Syst Conchyl.-Cab. Martini-Chemnitz, Bd. 1(Abt. 3, *Donacidae*, 1869, p. 56, Taf. 10, figs 1-3. "Fundort: Der Stille Ocean bei Cali fornien und Mittelamerika, (Nicoyia, Pana ma, Mazatlan, Reallejos)."

Type Locality: Gulf of Nicoya, Costa Rica

Range: Gulf of California to Panama.

Collecting Stations: Mexico: Santa Ine Bay, Gulf of California; Cape San Lucas Cape San Lucas Bay; Nicaragua: Potosi an Monypenny Point, Gulf of Fonseca; Corint (200-D-10, 16), 4-7 fathoms, mangrov leaves, also in beach drift.

Description: Shell elongately rhomboidal moderately inflated, fairly thick, obsolete ly finely radially grooved; anterior end th longer, acutely rounded, posterior en acuminately truncated, the extremity round ly pointed; posterior area concave; ventra margin rounded and somewhat expanded jus anterior to the middle, often with a com pressed area between this portion of th valve and the posterior angulation; inne margin crenulated; color white or brownish with the posterior and anterior dorsal area black or grayish-black; periostracum green ish.

One of the largest specimens, a right valve from the beach drift at Corinto, Nicaragua measures approximately: length, 21 mm. height, 10 mm.; convexity (one valve), 3.9 mm.; distance from beaks to posterior end 8.5 mm.

The shell of *Donax navicula* differs from that of *D. gracilis* in the more rounded base and rhomboidal form, more inflated valves and especially in that the posterior area i concave. It can be referred to the subgenus *Serrula*.

The concave posterior area and higher more triangular form are features which serve to separate *Donax navicula* from *D. californicus*.

Distribution: This species was taken abun dantly by the expedition in the beach drift at Corinto, Nicaragua. A few specimens were also taken as far north as Santa Inez Bay in the Gulf of California.

Donax obesus d'Orbigny.

Plate I, Fig. 7.

Donax obesa d'Orbigny, Voy, Amér

---

[39] *Donax punaensis* Pilsbry & Olsson, *Proc. Acad. Nat. Sci. Philadelphia*, Vol. 93, September 9, 1941, p. 72, pl. 12, fig. 2. "Pliocene of the north end of Puna Island." Ecuador.

[40] *Donax owenii* Gray in Hanley, Cat. Rec. Bivalve Shells, 1843, p. 81. "Africa?"—Reeve, Conch. Icon., Vol. 8, *Donax*, September, 1854, species 37, pl. 6, fig. 37. "Hab. West Coast of Africa."

Dall (*Nautilus*, Vol. 5, No. 4, August, 1891, p. 44), recorded this species from Montevideo and Maldonado. Maury (Serv. Geol. & Min. Brasil, Mon. No. 4, 1924, p. 455) also cited the species as occurring at Montevideo, Uruguay. Melvill & Standen recorded a species under the name of *Donax* (*Machaerodonax*) *owenii* Gray, from Karachi, India (*Proc. Zool. Soc. London*, November 13, 1906, p. 826). Carcelles recently cited *Donax owenii* as occurring along the coast of Argentina (Rev. Mus. de La Plata (New Ser.), Sec. Zool., Vol. 3, 1944, p. 303).

Mérid., Vol. 5, 1846, p. 541, pl. 81, figs. 28, 30. "Elle a été pêchée à Payta (Pérou) par M. Fontaine."—Reeve, Conch. Icon., Vol. 8, *Donax*, October, 1854, species 49, pl. 7, fig. 49. "Hab. Real Llejos, Central America; Cuming."

Donax obesus d'Orbigny, Sowerby, Thes. Conch., Vol. 3, 1866, p. 310, pl. 281 (*Donax*, pl. 2), figs. 42, 43. "Real Llejos, Central America."

Type Locality: Paita, Peru.

Range: Corinto, Nicaragua, to Paita, Peru.

Collecting Station: Nicaragua: Corinto (200-D-11, 19), 8-13 fathoms, mangrove leaves.

Description: Shell small, subtriangular, inflated; the anterior end the longer, sloping, acutely rounded at the extremity, posterior end broadly and roundly truncated; umbonal ridges rounded; ornamented with fine radial grooves which are crossed by somewhat flexuous concentric grooves forming a fine cancellated pattern of punctate appearance; inner margin finely crenulated; color white with dark purplish-brown on the posterior end and on the anterior dorsal margin.

The largest specimen in the collection, a right valve, measures: length, 13.4 mm.; height, 10.9 mm.; convexity (one valve), 4.2 mm.

The shell of *Donax obesulus* Reeve[41] is much more abruptly truncated than that of *D. obesus*, and the posterior umbonal ridge is decidedly angulated rather than rounded.

Distribution: This species was dredged by the expedition at two localities off Corinto, Nicaragua, at depths of 8-13 fathoms.

Donax punctatostriatus Hanley.

Plate I, Fig. 17.

Donax punctato-striata Hanley, *Proc. Zool. Soc. London*, Pt. 11, July, 1843, p. 5. "Hab.—? Mus. Stainforth, Metcalfe, Hanley, &c."—Hanley, Cat. Rec. Biv. Shells, 1843, p. 84, pl. 14, fig. 24 (as *Donax punctato-striatus* on expl. to plate). [Not the record "China"].—Reeve, Conch. Icon., Vol. 8, *Donax*, September, 1854, species 16, pl. 3, figs. 16a, 16b. "Hab. Mazatlan, Gulf of California."—Sowerby, Thes. Conch., Vol. 3, *Donax*, 1866, p. 310, pl. 281 (*Donax*, pl. 2), figs. 49, 50 (as *Donax punctato-striatus*). Reeve's locality cited on expl. to pl.

Type Locality: Mazatlan, Mexico (here designated as type locality). No locality cited originally.

Range: San Ignacio Lagoon, Lower California, to the Gulf of California and south to Negritos, Peru.

Collecting Stations: Mexico: Santa Inez Bay, Gulf of California; Cape San Lucas; Chamela Bay; Tenacatita Bay; Sihuatanejo; Tangola-Tangola Bay; Nicaragua: Gulf of Fonseca; Potosi and Monypenny Point; Corinto (200-D-19), 12-13 fathoms, mangrove leaves, also beach.

Description: Subtriangular, very convex, pale livid brown, with strong radiating punctated striae, becoming very fine and close on the anterior [posterior] slope, whose edge is rounded, posterior and anterior edges much sloping, ventral arcuated in the middle; inside stained with violet, the ventral margins dentated, the anterior [posterior] crenulated: two cardinal and lateral teeth in each valve. Long. 4/5—1-1/5 [inches] (Hanley, Cat. Rec. Biv. Shells, 1843). "When full grown less inequilateral than most of this genus."

A very large specimen of this species in the Henry Hemphill collection in the California Academy of Sciences, collected at Magdalena Bay, Lower California, measures: length, 44.8 mm.; height, 30 mm.; convexity (both valves together), 17.4 mm.

The subtrigonal form and the row of fine pits, which occur in the radial grooved striae, are characteristic features of this species. It belongs to the subgenus *Chion* Scopoli.

Hanley once reported *Donax punctatostriatus* from China but it was later recognized as occurring commonly in tropical west American waters.

The variety described by Carpenter as *Donax punctatostriatus* var. *caelatus*[42] appears not to have been recognized since its description. It was described as possessing short impressed lines rather than pits in the interspaces.

Sowerby (1866) pointed out that there are specimens which intergrade between *Donax punctatostriatus* and *Donax conradi* Reeve[43]. The latter species is now known to be identical with *D. contusus* Reeve[44] (see our Pl. I, fig. 14), as pointed out by Tomlin[45]. *Donax vellicata* Reeve (fig. 66) and *D. bitincta* Reeve (fig. 68), both described without information as to the locality from which they came, are likewise identical with *D. contusus* according to Tomlin.

Typical forms of *Donax punctatostriatus* are more subtrigonal and higher than those of typical *D. contusus*, which are lower and more elongate in outline. Large specimens of *D. punctatostriatus* are sometimes slightly expanded medially along the ventral margin and the posterior dorsal margin often slopes more steeply than that on *D. contusus*, but as mentioned by Sowerby, there is intergradation between the two forms. The most elongate form of this variable group is *Donax*

41 *Donax obesula* Reeve, Conch. Icon., Vol. 8, *Donax*, September, 1854, species 30, pl. 5, fig. 30. "Hab. Peru."—Deshayes, *Proc. Zool. Soc. London*, 1854 (issued May 16, 1855), p. 352. "Hab. Central America."

42 *Donax ?punctatostriatus*, var. *caelatus* Carpenter, Cat. Mazatlan Shells, September, 1855, p. 46. "Hab.—Mazatlan; very rare."

43 *Donax conradi* Reeve, Conch. Icon., Vol. 8, *Donax*, September, 1854, species 29, pl. 5, fig. 29. "Hab. Gulf of California."

44 *Donax contusus* Reeve, Conch. Icon., Vol. 8, *Donax*, September, 1854, species 24, pl. 4, fig. 24. "Hab. Mazatlan, Gulf of California."

45 Tomlin, J. R. leB., *Nautilus*, Vol. 40, No. 2, October, 1926, p. 52.

culter Hanley[46], as pointed out by Carpenter[47]. Very elongate forms of *D. culter* are somewhat reminiscent of *Amphichaena kindermanni* Philippi[48] as is *Donax petallinus* Reeve[49].

Donax aricanus Dall[50], recorded as occurring from Paita, Peru, to Arica, Chile, appears to be very similar to *D. punctatostriatus* and possibly some of the records of the occurrence of the latter species in South America may be referable to Dall's species. Römer considered *D. radiatus* Valenciennes [=*aricanus*] to be only a variety of *D. punctatostriatus*.

Donax striatus Linnaeus, which occurs in the Caribbean region, is a similar species.

Distribution: This species was collected by the expedition on the beach and dredged at depths of 12-13 fathoms, from Santa Inez Bay in the Gulf of California to Corinto, Nicaragua. It is a variable shell found commonly from the Gulf of California to Peru. It has been recorded as occurring in the Pleistocene of southern California, Magdalena Bay, Lower California, and at Oaxaca, Mexico.

Donax transversus Sowerby.

Plate I, Fig. 3.

Donax transversa Sowerby, Cat. Shells Tankerville, 1825, Ap., p. IV. [No locality cited].—Reeve, Conch. Icon., Vol. 8, *Donax*, September, 1854, species 36, pl. 6, fig. 36. "Hab.—?"

Donax transversus Sowerby, Sowerby, Thes. Conch., Vol. 3, 1866, p. 306, pl. 280 (*Donax*, pl. 1), fig. 11. "Hab.—?"—Carpenter, Cat. Mazatlan Shells, September, 1855, p. 44. Mazatlan, Mexico.

Type Locality: Corinto, Nicaragua (here designated as type locality). No locality cited originally.

Range: Mazatlan, Mexico, to San Juan del Sur, Nicaragua.

Collecting Station: Nicaragua: Corinto (200-D-19), 12-13 fathoms, mangrove leaves.

Description: "D. testâ transversim elongatâ, laevi; latere postico brevi, biangulato, carinato, obliquè truncato, longitudinaliter sulcato; extus albidâ; fulvo obsoletè radiatâ". (Original description).

The shell of this species is very elongated, very inequilateral, rather thin, moderately inflated, gaping at each end, polished and obsoletely radially striated; anterior dorsal margin slightly concave; anterior end elliptically rounded obliquely joining the slightly rounded ventral margin; posterior end truncated, set off by a carina, the area fairly broad, concave, with a faint rounded angulation medially, the whole area finely radially striated and at the end obliquely truncated; color yellowish-white with purple rays; ventral margin finely crenated.

Specimens of this species in the present collection are small. A large left valve collected at Corinto, Nicaragua, by the senior author measures: length, 36.4 mm.; height, 14.5 mm.; convexity (one valve), 4.5 mm.; distance from beak to posterior end, 14 mm.

This appears to be the species which authors have cited from western Mexico and Central America under the name of *Donax scalpellum* Gray. *Donax scalpellum* Gray[51] was originally described without information as to locality. Hanley[52] later cited it from "California" and Reeve[53] cited it from the Gulf of California. E. A. Smith[54] in 1891 cited it from Aden, in the Gulf of Aden, and stated: "The above named locality, given by Reeve (Conch. Icon. sp. 39), has never been confirmed, and I think there is little doubt that it is incorrect. The specimens from Aden agree in form, color, sculpture, and every other respect with that figured by Reeve." Later Melvill & Standen[55] cited the species as occurring at Karachi, India, in the Arabian Sea.

The concavity of the anterior dorsal margin, obliquely elliptically rounded anterior end, and much wider and radially striated posterior area are features separating *Donax transversus* from *D. scalpellum*. *Donax transversus* belongs to the subgenus *Machaerodonax* Römer, the type of which is *D. scalpellum* Gray.

Distribution: Three small specimens of *Donax transversus* were dredged by the expedition in 12-13 fathoms off Corinto, Nicaragua. It also has been collected by the senior author on the beach at the same locality.

---

[46] *Donax culter* Hanley, *Proc. Zool. Soc. London*, April, 1845, p. 14. "Hab. Var. a. Matzellan [Mazatlan] Gulf of California (Cuming). Var. b. Acapulco (Cuming)."—Reeve, Conch. Icon., Vol. 8, *Donax*, September, 1854, species 21, pl. 4, fig. 21. "Hab. Gulf of California."

[47] Carpenter, P. P., Cat. Mazatlan Shells, September, 1855, pp. 47-48.

[48] See Palmer, R. H., and Hertlein, L. G., *Bull. South. Calif. Acad. Sci.*, Vol. 35, Pt. 2, May-August (issued September 10), 1936, p. 71, pl. 18, figs. A, B, C, pl. 19, figs. 5, 6, 7, 8, 9, 10. Mazatlan; Petatlan Bay; Tenacatita Bay, Mexico, Recent. Also Oaxaca, Mexico, Pleistocene.

[49] *Donax petallina* Reeve, Conch. Icon., Vol. 8, *Donax*, October, 1854, species 51, pl. 8, fig. 51. "Hab.—?"—Deshayes, *Proc. Zool. Soc. London* for 1854 (issued May 16, 1855), p. 350 (as *Donax petalina*). "Hab.—? Coll. Cuming."

This species was described without information as to the locality from which it came. Bertin (*Nouv. Arch. Mus. Hist. Nat.* (Paris), Ser. 2, Vol. 4, 1881, p. 84), stated that he found an indication in Deshayes' collection that the species came from Chile. Dall, 1909, and Gigoux, 1934, also cited it from that country. Pilsbry & Lowe, 1932, and Bales, 1938, cited it from Acapulco, Mexico.

[50] *Donax radiata* Valenciennes, Rec. d'Obser. Zool. Humboldt & Bonpland, Vol. 2, 1832, p. 221, pl. 1, figs. 3a, 3b, 3c, 4. "Habitat in Oceano Pacifico ad Americae calidioris litora." Not *Donax radiata* Gmelin, 1791.

Donax aricana Dall, *Proc. U. S. Nat. Mus.*, Vol. 37, November 24, 1909, p. 273. New name for *Donax radiata* Valenciennes, 1832, not *D. radiata* Gmelin, 1791. Paita, Peru, to Arica, Chile.

[51] *Donax scalpellum* Gray, *Ann. Philos.*, Vol. 25, February, 1823, p. 136. [No locality cited].—Wood, Index Test., Suppl., 1828, p. 4, pl. 2, *Donax*, fig. 1. [No locality cited].

[52] Index Test. by W. Wood, edit. by S. Hanley, 1856, p. 202, Suppl. pl. 2, *Donax* fig. 1. "California."

[53] Reeve, L. A., Conch. Icon., Vol. 8, *Donax*, September, 1854, species 39, pl. 6, fig. 39. "Hab. Gulf of California."

[54] Smith, E. A., *Proc. Zool. Soc. London*, 1891, p. 427.

[55] Melvill, J. C., and Standen, R., *Proc. Zool. Soc. London*, November 13, 1906, p. 826.—Melvill, *Proc. Malacol. Soc. London*, Vol. 18, Pt. 3, 1928, p. 115.

Genus *Iphigenia* Schumacher.

Iphigenia Schumacher, Essai Nouv. Syst. Test., 1817, pp. 51, 155. Sole species, *Iphigenia laevigata* (*Donax laevigata* Chemnitz.). Ref. to Chemnitz, Vol. 6, p. 253, pl. 25, fig. 249. Illustrated by Schumacher on pl. 17, figs. 4a, b.—Dall, *Trans. Wagner Free Inst. Sci.*, Vol. 3, Pt. 5, 1900, p. 962. Type: *Donax laevigata* Chemnitz.—Pilsbry & Bequaert, *Bull. Amer. Mus. Nat. Hist.*, Vol. 53, Art. 2, May 9, 1927, p. 369. *Donax laevigata* "Chemnitz" Gmelin accepted as type.

Type (by monotypy): *Donax laevigata* Chemnitz [Neues Syst. Conchyl.-Cab., Bd. 6, 1782, p. 253, Tab. 25, fig. 249. "Es wohnet diese Muschel in den ostindischen Meeren. Bey Tranqueber wird sie nur selten gefunden". Also illustrated by Schumacher, pl. 17, fig. 4a, b].

Shell large, subtriangular, subequilateral, without radial sculpture; thick, with entire ventral margins; two cardinals, the larger bifid, in each valve and two obsolete laterals in the right valve. (Dall).

The genus *Iphigenia* is known to occur in the Miocene of Venezuela and Peru. At the present time it often occurs in estuarine or brackish water conditions and is known to occur in greatest abundance from the coast and rivers of West Africa and from the tropical Atlantic and Pacific coasts of Central and South America. *Iphigenia centralis* Germain, an African species, ranges from the middle Niger river to strongly saline waters. One species occurs on the coast of Florida and one species occurs in tropical west American waters.

Iphigenia altior Sowerby.

Capsa altior Sowerby, *Proc. Zool. Soc. London*, Pt. 2, for 1832 (issued March 13, 1833,) p. 196. "Hab. in Peruviâ et Americâ Centrali." "Dredged among coarse gravel, in twelve fathoms water, in the Gulf of Nocoiyo. A smaller variety, which is also rather higher, was found at Tumbez, at a depth of five fathoms, in thin mud."—Hanley, Cat. Rec. Bivalve Shells, p. 86, 1843, pl. 14, fig. 34, 1844, p. 349, 1856. Peru and Central America.—Römer, Syst. Conchyl.-Cab. Martini-Chemnitz, Bd. 10, Abt. 3, *Donacidae*, 1869, p. 114, Tab. 21, figs. 1-4. Earlier records cited.

Iphigenia ambigua Bertin, *Nouv. Arch. Mus. Hist. Nat.* (Paris), Ser. 2, Vol. 4, 1881, p. 120, pl. 4, figs. 4a, 4b, 4c . . . "habite l'océan Pacifique, sur les côtes de l'Amérique centrale."

Iphigenia altior Sowerby, Dall, *Proc. U. S. Nat. Mus.*, Vol. 37, 1909, p. 159, pl. 25, fig. 8. Capon to Tumbez, Peru. Range, Gulf of California to Tumbez, Peru.

Type Locality: Gulf of Nicoya, Costa Rica, in 12 fathoms, coarse gravel. Tumbez, Peru, also cited originally for a small variety of this species.

Range: Gulf of California to Tumbez, Peru.

Collecting Stations: Mexico: Chamela Bay, beach; Nicaragua: Potosi and Monypenny Point; Corinto, beach; Costa Rica: Port Culebra; Culebra Bay; Golfito Bay; one mile south of Golfito Bay.

Description: Shell subtriangular, the anterior side the longer, thick, moderately inflated, base rounded, anterior dorsal margin gently arcuate and sloping, rounded at the end, posterior dorsal margin more steeply sloping, more flattened and subtruncated at the end, a slight depression often present anterior to the posterior umbonal ridge; smooth except for lines of growth and submicroscopic radiating striae; two cardinal teeth in each valve, the right posterior and left anterior bifid or medially grooved; inner margin smooth; pallial sinus extends for about five-eighths the length of the shell, rounded at the end, and along the base for about a third of its length confluent with the pallial line; color yellowish or purplish-white under an olive periostracum, the umbos dark, the interior white and violet.

A very large right valve in the present collection from one mile south of Golfito Bay, Costa Rica, measures: length, 79 mm.; height, 57.3 mm.; convexity (one valve), 18 mm.; pallial sinus extends anteriorly 45 mm. from the posterior margin of the shell. A specimen in the collection of the California Academy of Sciences collected in Panama Bay by F. M. Anderson, measures: length, 68 mm.; height, 51.5 mm.; convexity (both valves together), 31 mm.; pallial sinus extends anteriorly 39 mm. from the posterior margin of the shell.

The specimen described as *Iphigenia ambigua* by Bertin may be slightly longer in proportion to the height as compared to some specimens of *I. altior*. In the absence of any other differences and in view of the variation shown in a series of shells, we have placed Bertin's species in the synonymy of *I. altior*. Carpenter[56] mentioned an elongate specimen from Mazatlan with a strong posterior ventral sinus which he referred to *"Iphigenia ?laevigata,* ?cujus." According to Carpenter, Gray considered the specimen to be an abnormal variety of *I. altior*. In general features *I. altior* is quite similar to *I. laevigata*, the type of the genus, from West Africa.

Compared to *Iphigenia brasiliana* Lamarck, which occurs in the Caribbean region, the shell of *I. altior* is considerably higher proportionately from beak to base and it has a much fainter depression anterior to the posterior truncation.

Distribution: Specimens of *Iphigenia altior* were collected by the expedition on beaches from Chamela Bay, Mexico, to Golfito Bay, Costa Rica. Dall mentioned that this species was found at a depth of 4 to 6 inches in sand, on flats and tidal lagoons of Peru.

[56] Carpenter, P. P., Cat. Mazatlan Shells, September, 1855, p. 42.

EXPLANATION OF THE PLATE.

Fig. 1. *Donax navicula* Hanley. Hypotype, left valve, from Corinto, Nicaragua. Length, 18.8 mm.; height, 9.2 mm. P. 254.

Fig. 2. *Donax californicus* Conrad. Hypotype, left valve, from San Pedro Bay, California. Length, 22 mm.; height, 9.8 mm. P. 252.

Fig. 3. *Donax transversus* Sowerby. Hypotype, left valve, from Corinto, Nicaragua. Length, 36.6 mm.; height, 14.5 mm. P. 256.

Fig. 4. *Donax gracilis* Hanley. Hypotype, left valve, from Potosi and 5 miles west of Monypenny Point, Nicaragua. Length, 22 mm.; height, 9.7 mm. P. 253.

Fig. 5. *Donax californicus* Conrad. View of right valve of the specimen shown in Fig. 2.

Fig. 6. *Donax gracilis* Hanley. Hypotype, left valve, from Loc. 27588 (C.A.S.), about 13 miles southeast of Cape Tosco, Santa Margarita Island, west coast of Lower California. Collected by the Templeton Crocker Expedition, 1932. Length, 15.8 mm.; height, 7.3 mm. P. 253.

Fig. 7. *Donax obesus* d'Orbigny. Hypotype, left valve, from Station 200-D-19, Lat. 12° 28′ 03″ N., Long. 87° 12′ 39″ W., Corinto, Nicaragua, in 12-13 fathoms (22-24 meters). Length, 11.1 mm.; height, 8.9 mm. P. 254.

Fig. 8. *Semele sparsilineata* Dall. Hypotype, left valve, from Station 221-D-1, Lat. 7° 54′ 45″ N., Long. 82° 04′ 32″ W., Gulf of Chiriqui, Panama, in 35 fathoms (64 meters). Length, 22 mm.; height, 17.4 mm. P. 247.

Fig. 9. *Donax carinatus* Hanley. Hypotype, left valve, from Corinto, Nicaragua. L. G. Hertlein, coll. Length, 36.3 mm.; height, 18.2 mm. P. 253.

Fig. 10. *Semele quentinensis* Dall. Hypotype, right valve, from Station 199-D-1, Lat. 13° 08′ N., Long. 87° 43′ W., Meanguera Island, Gulf of Fonseca, El Salvador, in 16 fathoms (29 meters). Length, 26.4 mm.; height, 21.1 mm. P. 246.

Fig. 11. *Semele pacifica* Dall. Hypotype, right valve, from Golfito, Gulf of Dulce, Costa Rica. Length, 19.4 mm.; height, 15.4 mm.

Fig. 12. *Semele jaramija* Pilsbry & Olsson. Hypotype, left valve, from Santa Inez Bay, Lower California, in the Gulf of California, on shore. Length, 16.1 mm.; height, 12 mm. P. 244.

Fig. 13. *Semele venusta* Reeve. Hypotype, right valve, from Station 196-D-8, Lat. 15° 45′ 37″ N., Long. 96° 05′ 54″ W., Tangola-Tangola Bay, Mexico, in fathoms (16.3 meters). Length, 17. mm., height, 13 mm. P. 248.

Fig. 14. *Donax contusus* Reeve. Hypotype, left valve, from Loc. 27230 (C.A.S.), Petatlan Bay, Mexico, about 6 miles south of Sihuatanejo. L. G. Hertlein, coll. Length, 39.1 mm.; height, 20 mm. (Illustrated for comparison with *Donax punctatostriatus*, Fig. 17). P. 255. (in text).

Fig. 15. *Semele pulchra* Sowerby. Hypotype, right valve, from Potosi and 5 miles SSW. of Monypenny Point, Nicaragua. Length, 31 mm.; height, 26 mm. P. 240.

Fig. 16. *Abra palmeri* Dall. Hypotype, right valve, from Station 199-D-1, Lat. 13° 08′ N., Long. 87° 43′ W., Meanguera Island, Gulf of Fonseca, El Salvador, in 16 fathoms (29 meters). Length, 9. mm.; height, 9 mm. P. 250.

Fig. 17. *Donax punctatostriatus* Hanley. Hypotype, left valve, from Loc. 4859 (C.A.S. H. Hemphill coll.), Magdalena Bay, Lower California. Length, 44.4 mm. height, 28 mm. P. 255.

Fig. 18. *Abra palmeri* Dall. View of the interior of the specimen shown in Fig. 16.

Fig. 19. *Semele craneana* Hertlein & Strong sp. nov. Holotype, left valve, dredged in the Gulf of California. (Exact station unknown but probably in the southern portion of the Gulf of California). Length, 38 mm.; height, 29. mm. View of the interior. P. 241.

Fig. 20. *Abra palmeri* Dall. Hypotype, left valve, from Station 199-D-1, Lat. 13° 08′ N., Long. 87° 43′ W., Meanguera Island, Gulf of Fonseca, El Salvador, in 16 fathoms (29 meters). Length 10.5 mm.; height, 9.3 mm. View of the interior. P. 250.

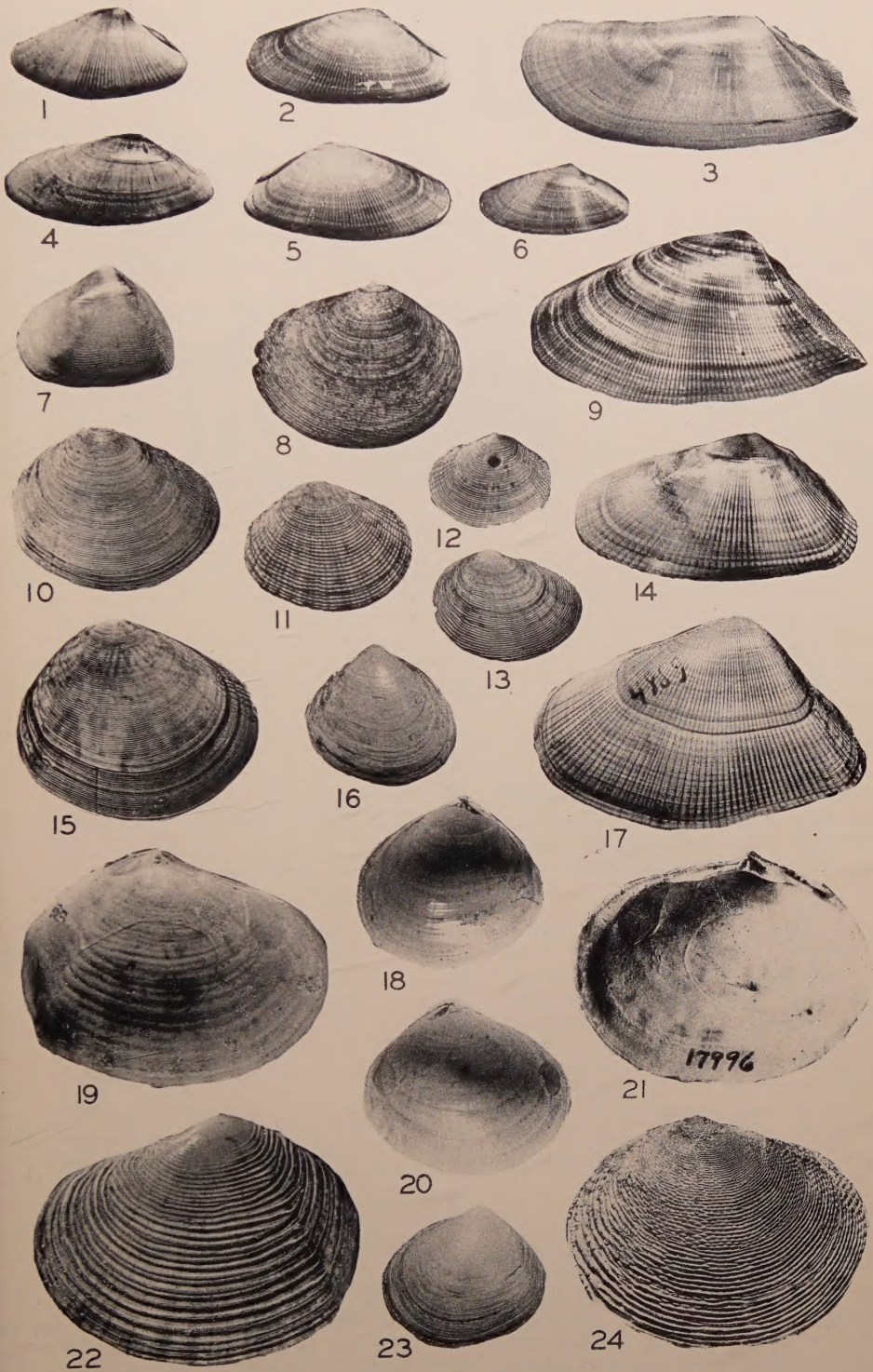
Fig. 21. *Semele verrucosa* Mörch. Hypotype, right valve, from Station 224, Lat. 7° 23′ 30″ N., Long. 82° 03′ W., Hannibal Bank, Panama, in 35-40 fathoms (64-73 meters). Length, 43 mm.; height 32.8 mm. View of the interior. P. 249.

Fig. 22. *Semele craneana* Hertlein & Strong sp. nov. Holotype. View of the exterior of the specimen shown in Fig. 19.

Fig. 23. *Abra palmeri* Dall. View of the exterior of the specimen shown in Fig. 20.

Fig. 24. *Semele verrucosa* Mörch. View of the exterior of the specimen shown in Fig. 21.

All the specimens illustrated on this plate are in the type collection of the Department of Paleontology of the California Academy of Sciences.



MOLLUSKS FROM THE WEST COAST OF MEXICO AND CENTRAL AMERICA. PART VIII